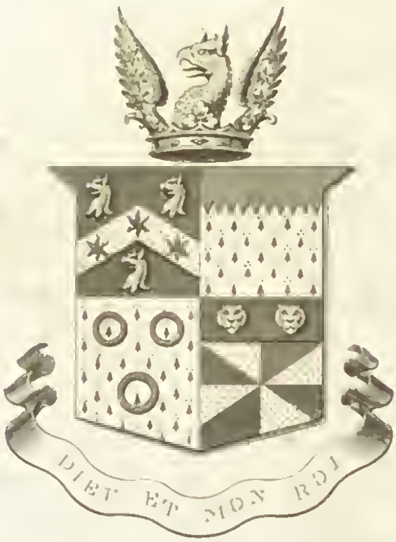

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A SYSTEM OF GYNECOLOGY AND OBSTETRICS

BY AMERICAN AUTHORS.

EDITED BY

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OBSTETRICS.

VOLUME I.—PART I.

ILLUSTRATED WITH WOOD ENGRAVINGS.

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PREFACE.

The very marked favor which has been shown to composite systematic treatises on medicine has placed the verdict of professional approval on works which realize the ideal advantages of this most attractive plan. Obstetrics, certainly not less important than any other branch of medicine, has not yet been dealt with in this manner, at least by the present generation in America. It is with great pleasure, therefore, that the Editor presents to the profession the first half of a work which will cover the entire subject of Obstetrics, and will embody the knowledge of well-recognized authorities among our countrymen whose teaching is especially adapted to our own conditions and surroundings. For the views expressed the contributors are well able to answer, and in the few instances where conflicting statements are made, it is simply an indication that there is upon those points room as yet for a difference of opinion.

In pursuance of the intention to provide the obstetrician with a complete guide to the discharge of his responsibilities, space has been assigned to departments not directly operative or therapeutic. A perusal of the first two articles will prove their eminent fitness to form an integral part of every practitioner's equipment.

Special attention has been paid to the illustrations, some of which represent the best selections from the vast literature of Obstetrics, while by far the larger number are engravings carefully executed from original sketches and photographs.

To Dr. Mann, the Editor of the *System of Gynecology by American Authors*, I am greatly indebted for the courtesy which allowed the *System of Obstetrics by American Authors* to be associated with his charge. A familiarity with the contents of both volumes now published has only strengthened a belief based on the reputation of the eminent gentlemen contributing to the *Obstetrics*, that the present work would attain the high standard set by the *Gynecology*, and that the two treatises would be recognized by professional opinion as kindred on cognate subjects.

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HISTORY OF OBSTETRICS.

By GEO. J. ENGELMANN, M. D.,

St. Louis, Mo.

The history of Obstetrics possesses a peculiar interest, and one by far more general than that of any other branch of medicine, as its status and its progress are so intimately blended with the condition of the people and the progress of their civilization. The obstetric art, the assistance rendered during the act of parturition, the care of mother and child, is a necessity at all times. This branch of medicine applies to the physiological as well as the pathological state, and thus differs from all others the exercise of which is confined to morbid conditions. However remote the period, however crude or primitive the people, in ancient times or modern, aid was given childbearing woman: in the simplest cases certain manipulations were necessary, performed perhaps by the patient herself.

The obstetric art, like that of surgery—the healing of wounds—can be traced through the earliest records, and of necessity received attention from the most primitive peoples: long before an art of medicine existed women who had themselves borne children, taught by experience, assisted their neighbors, as the warrior or the hunter, exposed to injury himself, rendered surgical aid to his fellow-man.

The obstetric and the surgical arts were the first needed, and of all branches of medicine the most capable of development, by primitive peoples dealing with parts exposed, open to view. Obstetric art, first and most frequently called for, attained a certain perfection at an early day, but not a single step forward was taken for two thousand years—from the time of Hippocrates in Greece and the Ayur Veda in India until Paré and Vesalius laid the foundation for the modern scientific school.

It was woman who gave aid to her sister in childbirth: the obstetric art was in the hands of women—women of low caste: it was looked upon as woman's work, and progress was thus impeded if not impossible. Whilst the aid of the priests, or men possessed of mystic powers, was sought for in difficult cases, they were at other times carefully excluded from the lying-in room, and thus prevented from gathering the experience necessary for progressive innovation. It was eminently the sphere of woman, and so considered until the era of modern scientific medicine. We need but recall the fate of Dr. Wertt of Hamburg, who in 1522 put on the dress of a woman to attend and study a case of labor, and was burned alive for his pains; or that of Dr. Willughby, one hundred years later, who assisted his daughter, a midwife, in a difficult labor, and was obliged to crawl into the darkened room on hands and knees. The title of mæntai—man-grandmother—was given by the Greeks in the time of Hippocrates (400 B. C.) to men called in in difficult cases; this spirit pervaded up to the scientific period, as indicated by the appellation of "man-midwife" given to Chamberlain, the inventor of the forceps, in the middle of the sixteenth century; and the adherence, even now, of the mass of the people to the midwife in the older countries, shows how deep-seated a feeling this is. During that entire era of empiricism progress was possible only as far as the eye could reach: the most important parts were concealed, the mechanism only to a slight degree exposed. Without means of penetrating or bringing to view the mystic process, actual progress was out of the question, and did not take place until the scalpel opened the way and medical men entered upon the practice of the art in the middle of the sixteenth century.

The obstetric art, beyond any one of the branches of medicine, appeals to the sympathies and to the most sacred instincts. We may look to the obstetric practice of a people as indicative of their civilization, their culture, and their morale. However crude they may be, however primitive their obstetric practice, their character is revealed by the care which they give childbearing woman. I have looked upon the rapid development of the obstetric art in France in the time of Levret as due not alone to the scientific activity of the country at that period, but equally, if not more, to the more elevated position occupied by woman. And is not the prevalence of obstetric practitioners in this country the reflex of the social status of woman? In America the practice of obstetrics was considered not alone as worthy of the physician, but as one of the most important branches of his art, and in this country confinements among native-born women have as a rule been conducted by physicians, in striking contrast to the older countries, where until quite recently, even among the higher classes, the treatment of women in labor was the province of the midwife.

During the sway of what I have called natural or empirical obstetrics, from the earliest times to 1550 in Europe, we find the status of this art a striking index to the condition of the people and entirely independent of the development of the medical science; but with the appearance of scientific midwifery this characteristic is gradually effaced, and dies out with the growing importance of anatomical and physiological knowledge: with the supremacy of the male practitioner, the scientific obstetrician, local and national peculiarities gradually fade away and the obstetric art assumes a more important position among the branches of medical science. Not until now, until this present era of scientific medicine, has it been thoroughly recognized and merged with other branches of medicine, and to-day obstetric science ranks as one of the most important branches of medicine. Yet side by side with the higher development of the art in our present civilization the various epochs of the empirical stage through which it has passed in its development still persist; obstetric art as it existed before the time of the Pharaohs, and previous to the time of Greek civilization, is faithfully preserved among races and people of a more primitive civilization: side by side with antiseptic midwifery, the perfected Cæsarean section, and the axis-traction forceps all the epochs of the empirical period are represented, to the very earliest, the primitive or intuitive practice, as it must have existed in Egypt before the times of the earliest papyrus or in Greece before the time of Homer. Among our Indians and the negroes of Africa obstetric art persists in its primitive or intuitive state, and, though the religious epoch possesses no characteristic exponent at the present day, the more advanced epoch as represented by the fathers of medicine has not yet been surpassed among the Chinese and other nations of the East, which fairly represent the progressive pre-anatomic period.

I have not adopted the various periods of time usually accepted in obstetric history, but have classified by epochs of progress, considering as *natural* or *empirical obstetrics* the art as practised from the earliest times to the middle of the sixteenth century among European nations, and still retained by nations less advanced. This is of historic interest only: the *scientific period* begins with the rediscovery of podalic version by Ambroise Paré in 1550, gradually developing with the study of anatomy and physiology and with the acceptance of the obstetric art as one of the branches of medical science, progressing as empiricism gives way to scientific research and the ignorant midwife to the scientific physician.

I have sketched only the great epochs which are indelibly characterized and readily recognized, many even now coexisting with our advanced science in the same crude state as we find them in the earliest records thousands of years ago. Less important epochs I cannot here recognize, as such minor fluctuations are without bearing upon the progress and the future of an art, and of interest only to the critical student of individual features.

Only within late years have we received a clear insight into the earlier history of obstetrics by the light of ethnological research. The study of the obstetric practice of primitive peoples of the present has lifted the veil of mystery which has heretofore clouded our knowledge of early obstetric art; recent observations serve to explain the scanty notes contained in early records, so that we now have a fairly perfect picture of obstetric practice among the nations of antiquity. The customs of primitive peoples now existing reflect the earliest practice, from which the later more refined, but by no means always improved, methods have developed.

For the earliest epoch I have drawn freely upon my work on labor among primitive peoples,[1] and dwell more at length upon these hitherto unknown methods, as there is much that is extremely suggestive in the intuitive practice of the earliest epoch, in the crude attempts to correct malposition in pregnancy, in the numerous methods of external expression, the removal of the after-birth by pressure, contraction of the uterus by heat and cold externally applied, the practical features of antisepsis which appear in the isolation of the puerpera and the thorough cleansing immediately after labor, the parching of the cord and the toasting of the maternal parts by fire; abortion resorted to to prevent an undesirable increase; in case of difficulty threatened in labor even the Cæsarean section is performed. In the very earliest epoch and among uncivilized peoples to-day we find most excellent methods, imperfect only for the want of anatomical knowledge, which have been lost in the attempted refinement of an earlier civilization. Instinct has developed the obstetric art among crude peoples to a perfection far greater than that of any of the medical sciences, and in the most primitive epoch we find methods which have recently assumed importance after their discovery and perfection by the scientific practitioner.

To the student the empirical period is extremely attractive and instructive, whilst the interest of the physician is centred upon the scientific period, the period of our present obstetric art from the rediscovery of podalic version in the middle of the sixteenth century to the present period of antiseptic midwifery with its wonderful achievements.

I. Empirical or Natural Obstetrics.

All obstetric practice based upon empiricism, lacking an anatomical and physiological foundation, I have considered as natural in contradistinction to the scientific. Though various degrees of refinement exist, determined by the varying civilization of the people, the practice of the obstetric art has changed but little up to the middle of the sixteenth century, the termination of this period among the people of the

[1] Engelmann: *Labor among Primitive Peoples*, St. Louis, 1883; Vienna, 1884; Paris, 1885.

Western civilization. Among primitive peoples, ancient and modern, and during an earlier civilization, the same general characteristics prevail: obstetric practice is in the hands of women; the expulsion of the child is furthered by external manipulations and posture of the patient, aided by nauseating internal medication; during labor, and even during pregnancy, more or less crude efforts at cephalic version are made in malposition by succussion and shaking, by pressure and posture. No efforts at preservation of the child's life are made; external violence and nervous shock or mental impressions are the last resort: placental expression is practised, so also abortion. With a beginning of anatomical and physiological knowledge we find a certain refinement of manipulation; strict cephalic presentations alone are hopeful, all others abnormal, and almost necessarily fatal to mother and child; the obstetric chair takes the place of human support and posture; methods for destroying the child, embryotomy, are developed, but many of the best intuitive practices are lost.

Three well-defined epochs mark the slow development of obstetric art throughout this entire period of empirical practice, and, notwithstanding the extremes of culture and civilization and the centuries of time throughout which this has persisted, the changes practically wrought are but slight.

The primitive or *intuitive epoch*, the earliest and most interesting, is characterized by the simplest and crudest external manipulations, all purporting to assist the natural *vis a tergo*—all the result of that intuitive mechanical skill which we respect and admire in the products of early art.

In the second, which I have termed *the religious epoch*, very much the same practice persists, with a certain refinement, and in difficult cases the intervention of the priests, whose assistance was sought in part for the sake of the mystical powers they are supposed to possess, and in part for the knowledge and skill possessed by this learned caste.

This epoch, though still persisting at the present day, was represented in its highest development by the earliest civilization of India, of Egypt, and of Greece, and in the latter country persisted to the time of Hippocrates (400 B. C.). This is the period to which our earliest records reach. The midwife appears; surgical instruments, especially for destructive purposes, were used; and at the height of this epoch obstetric art was taught within the precincts of the temple. The importance of the different positions was known: the cephalic presentation alone was considered favorable, and all efforts were directed toward the conversion of other presentations into this by cephalic version, always recommended, but never well defined. The last resort was embryotomy.

The most advanced is the third, *the progressive, pre-anatomic, epoch*, which is the predecessor of our present obstetric art, beginning with the time of Hippocrates, and continuing, among the civilized nations of the West, to the middle of the sixteenth century. The practice is still in the hands of women, mostly uneducated, but the medical profession appears distinct from the priesthood, and is looked to for help in difficult cases. With a superficial knowledge of anatomy and physiology we see an improvement in obstetric practice, which is, however, still very primitive as compared with the remarkable development of the surgical art at that period. Anatomical knowledge had not penetrated below the surface and opportunities of study were wanting: cephalic presentations were still looked upon as the only hopeful ones; cephalic versions, theoretically taught, gave no tangible results; and embryotomy still remained the last resort. A great many instruments were invented for the purpose, and this operation was developed to the utmost possible perfection; it was the one most frequently, if not *the only one*, performed by the physician; hence it is but natural that obstetric art retained its subordinate position as a branch of surgery.

In the three epochs of empirical practice, even in the earliest, most excellent methods are more or less crudely indicated, and correct manipulations, which have been rediscovered of late by the light of our present medical science, are intuitively practised. Thus, Cæsarean section is skilfully practised by the negroes of Africa, and was known to the Israelites—the Dotze-Joffan—performed on the living, and made obligatory after sudden death during pregnancy by their religious laws, as it was likewise ordained by Buddhism, described in the Ayur Veda of Susruta. Isolation of the puerperal woman we see in the earliest epochs, both as the result of instinct and of religious laws: the Ayur Veda tells us that in India (1500 B. C.) a separate room was assigned the lying-in woman, and women of a higher caste were taken to an especial building for the purpose of confinement. In the interior of Russia a separate house is provided for the patient; the Comanches and other of our Indian tribes construct a shelter, a *wick-e-up*, some distance from the village, inside of which are two rectangular excavations: in the one is placed a *hot* stone, for steaming; in the other, loose earth to receive the discharges—perfect antiseptic practice. The inhabitants of Ceram, many of the African tribes, like those of Loango, are so confined, and are kept apart from their husbands and the villagers for weeks afterward. Intra-uterine injections were practised by Hippocrates: Polybius even attempted the artificial extra-uterine development—a process of hatching, we may say, of the fœtus after early expulsion. Now and then we find examples of prominent medical men attending important labor cases, as Antonius Musa, it is claimed, was summoned by the emperor Augustus to attend his wife Livia in confinement. Notwithstanding the wonderful perfection sporadically attained, a healthy and permanent development of obstetric art did not take place until a firm foundation was given by the study of anatomy and physiology: the discoveries of Paré and of Vesalius inaugurated the new era of scientific obstetrics, which was rapidly furthered in its infancy by the introduction of the *vis a fronte*, the forceps, by Chamberlain and Palfyn. Throughout the entire empiric period the *vis a tergo* alone was regarded: the abdominal muscles were looked upon as the moving force, and these were assisted by the hands of the aid.

A. PRIMITIVE OR INTUITIVE EPOCH.

Of the intuitive epoch we have no historic record. It is the practice which we find among the savages of the present day, and even now rapidly yielding to the progress of civilization, most perfectly developed among the crudest peoples, who for ages have not been contaminated by contact with any of the so-called more civilized nations. Among those who are most simple in their habits, apparently most primitive, where we find an intermingling of sexes in almost complete nudity, we are likely to find the highest morality, the greatest respect shown to woman in pregnancy and childbirth, and the most perfect attention to her wants. The customs, rather than the character of the manipulations, vary with the peoples and are determined by their peculiar habits and culture.

Siebold, in his history of obstetrics, written in 1839,[1] says that but little is known of primitive practices, yet admits that some few manipulations must have existed: the cord must have been cut, the after-birth removed, and the baby dressed. Records of obstetric practice of this epoch are indeed scant, and the few references of the Bible, the teachings of Susruta (1500 B. C.), pertain to the more advanced religious epoch. But since the time of Siebold adventurous travellers have fully revealed the remarkable development of the intuitive practice among the crudest peoples—an obstetric art which will soon be lost, and is fading away before the destructive progress of our civilization, like the arts and industries of these peoples. This is as true of the natives of India and of the African negro as it is of the American Indian. With the mental and physical deterioration which naturally follows the advent of civilization, the care of the childbearing woman decreases; the same attention is not given her, the same effort is no longer made, and, moreover, the legendary intuitive practices yield to the customs of the white man, whom they imitate and whose help is sought.

These simple people, with their primitive resources, were by no means as helpless as it might appear at first sight: labor was more natural, and the patient was exposed to fewer dangers, as the difficulties of

[1] *Versuch einer Geschichte der Geburtshülfe*, von Ed. Casp. Jac. von Siebold, Berlin, 1839.

childbirth increase with the progress and civilization of a people. This is not due so much, as is often claimed, to the degeneracy of humanity brought about by softness and luxury, as it is to the danger of infection in crowded localities and the increasing disproportion of passage and passenger, changes in the relationship between head and pelvis being brought about by the mixture of races, and deformities of the pelvis by poor and unhealthy living. From dangers of infection primitive people are guarded by natural instinct, the impulse to undergo their suffering in secluded places, and the plunge into lake or stream which usually follows delivery. Deformities of the pelvis are comparatively unknown, as they are due in the main to diseases which result from the crowding of civilization; a disproportion between the fœtal head and the maternal pelvis is rare, as the intermingling of races, and even of tribes, is almost unknown; hence the formation of the head corresponds to that of the pelvis. The dangers which result from miscegenation are so well known to the natives wherever an intermarriage with whites takes place, as it does upon the borders of civilization, that the confinement of a native mother with a child by a white father is looked upon invariably as dangerous, if not necessarily fatal, as among the Indians upon the Pacific coast, the African negroes who are in contact with settlers, and the natives of the oceanic islands; hence abortion in the early months is often resorted to. The intuitive practice of primitive peoples has long since solved the problem of prophylaxis in dangerous labor which the professors of obstetric science have but recently settled, and which was seriously questioned less than one hundred years ago. In Europe and America, in our present civilization, so thorough an intermingling has taken place by the varied supremacy of different nations and their far-reaching conquests that a simple natural labor, such as we find among a tribe of primitive people, is no longer possible. A pure type of individual races and tribes no longer exists, but, fortunately, modern science by version and the forceps has more than met the difficulties caused thereby.

Characteristics of Intuitive Practice.—The necessary aid in labor is rendered by women, by friends and neighbors, usually by older women with greater experience; manipulations are practised or religious customs observed during pregnancy for the preservation of the child and the attainment of an easy labor. Abortion is practised by external and even internal manipulations if for some reason dangers in confinement are anticipated or an increase of the family is to be prevented. Labor is supposed to be a voluntary act upon the part of the child, due to its desire to escape from its confined quarters; and, strange to say, this belief, existing among the Indians of the present day, can be observed in the earliest writings even in the advanced medical practice of the early civilization and more or less throughout all periods up to that of our present scientific obstetrics. The character of the labor was due to the disposition of the child: all difficulties were referable to its evil disposition. Even in France the time is not long past when the voluntary actions of the fœtus were spoken of, and when the cause of labor-pains and the expulsion of the child was looked for in the desire of the fœtus to change its condition of life—a belief which harmonizes most fortunately with the earlier epochs of obstetric practice, as it afforded good grounds for the destruction of the fœtus by efforts at expression, later by embryotomy, as a child so perverse as to refuse absolutely to appear merited death, as did the mother who carried such a child.

The main aid rendered was by the varying posture in different stages of labor, and by pressure upon the abdomen by the hands of the assistant—by kneading, shampooing, stimulation of the uterine muscles, and actual pressure to force out the uterine contents; nauseating drugs were also given to further expulsion. Fumigations with aromatic herbs were made to soften the parts, and a tardy placenta was expelled by massage by the hands of an assistant, by the patient herself, by compression of the abdomen by a belt or the end of a pole; the os is even dilated by the hands, and traction upon the cord is occasionally observed; but never is this alone relied upon for removal of the after-birth: this practice, so common among our midwives, is one of the evils of partial progress. Primitive peoples practised expression, or the expectant method, which is also known to midwives in some rural districts to-day: the cord was tied to the toe of the patient, so that gradual traction was made by extension of the leg; the same end was accomplished by attaching the cord in other ways—a truly expectant method; the patient knows that something is being done, and Nature will in time act. Contraction of the uterus post-partum is accomplished by kneading, by spraying of the abdomen with water skilfully thrown through the teeth or from a jug, and the cleansing by a plunge into the neighboring stream, always possible, as the border of a lake or the bank of a river was the favorite place for women in search of a solitary confinement, and the early habitations were all near the water. Even the binder is used here and there among primitive peoples, known as the squaw-belt among the Sioux tribes, applied either before the expulsion of the child or of the placenta, and worn until the next day. The Kiowas and Comanches wear a broad bandage of buckskin, which is applied immediately after the completion of labor and is worn for about a month. In Old Calabar a handkerchief is tied around the abdomen, the knot being placed over the hard contracting womb.

Various practices exist as to the period of rest during the puerperium: some return to their ordinary occupation the moment they escape from the scene of the labor or immediately after their plunge into the water; but among many peoples there is a certain time of rest and isolation, which becomes more thoroughly defined as the religious epoch is approached, an intuitive belief in the uncleanliness of the menstruating and puerperal woman existing, which takes shape in the religious idea of uncleanness. A period of rest is given the young mother by the unwritten laws of the people, and accorded her by religious authority in the more advanced epoch, during which she can attend to herself and her child. Some of our Indians seek to cleanse themselves by frequent steaming, others by washing; the Siamese and others, by a purification by fire. Among the Kalmucks the woman is regarded as unclean for three weeks after delivery, but never permitted to remain in her bed longer than seven days. The northern tribes of Russia, the Samoyedes and others, consider the puerpera unclean for several months after confinement, and after the expiration of two months she herself and the tent in which the confinement took place are thoroughly smoked, and from that time on considered clean. Is this not antisepsis in advance of private obstetric practice of the present day, and equal to that of the best-regulated maternity?

With regard to the umbilical cord, very much the same difference of practice exists in this intuitive epoch as it does at the present day: heat is frequently used, and to a most excellent purpose, to purify and further uterine contraction. The Rouconyennes woman takes a steam-bath in a hammock, and under this a large hot stone is placed, upon which water is thrown; the Annamite has a vessel filled with hot coals placed under her bed, and a fire kept going night and day, the stomach being rubbed twice a day with a vessel filled with hot coals. A pot of charcoal is placed at the door of the house on the end of a long pole as a sign of labor, and *entry is forbidden to those whose labors have been difficult or in whose families death has attended labor.* (Do we at the present day, in our most civilized communities, do as much to prevent the danger of infection?) The puerpera in Annam takes a decoction of laxatives and purgatives, and during the month of her childbed her husband abstains from all work and must give his attention to wife and child; the mother cannot leave the house before four weeks.

Intuitive practice, like that of the most learned obstetricians, varies with regard to the time of cutting the funis and the length of the remnant to be left. As a rule, the cord is not severed until labor is completed and the secundines are expelled. In the more advanced practice, until recent researches proved the harm to the child, the cord was cut and tied immediately after expulsion. Among many of our Indians and the Sandwich Islanders the child remains on the ground in front of the mother until the placenta is delivered. Among the Kiowas, Comanches, and others the assistant takes the cord between her fingers and squeezes such blood as may remain in it back toward the placenta, and not until then is the cord cut and tied. The Flatheads, Crows, and Creeks cut the cord at once. The natives of Syria wait twenty or thirty minutes before cutting the cord, but if the after-birth is not expelled by that time, it is severed and the patient put to bed; the Wakamba, in Africa, use threads of the bast of the monkey-bread tree, and tie the funis tightly two or three inches from the navel; the Mexican Indians, some three inches; the Comanches tie it about a foot from the body of the child. The Waswahili of Africa leave the cord very long and allow it to dry slowly; the Loango of Middle Africa cut it short and dry it rapidly, severing it at double the length of the first joint of the thumb, after which the child is taken to the fire and the remnant of the funis steadily pressed by the warm fingers of the attendant so as to hasten its drying, which is completed in twenty-four hours; then the withered mass is forced off with the thumb-nail and burnt. (A better practice than that now prevalent, and corresponding to the most recent antiseptic treatment of the cord by Dorhn.) The Syrians tie both sides; the Blackfeet ligate the fœtal end, but take the precaution to pinch the protruding placental end of the funis with the fingers, so as to prevent oozing. Dull instruments are usually used for cutting the funis, a bruising and crushing rather than cutting, thus preventing hemorrhage; the Klamath and other Indians chew off the cord. These customary procedures, now traditional superstitions, must have originated in some thinking mind, and good reasons have existed for their use.

In the management of the after-birth the superiority of primitive intuitive practices over all later refinements is well marked: the Australian woman squats down, in a small excavation in the ground prepared for that purpose, as in defecation—a favorite position among primitive peoples at this period of labor, as many of the muscles come into play which serve in the expulsion of the feces; the Sioux compress the abdomen with a belt; other Indians and some of the negroes of Africa use massage or the shampoo, and almost all manual expressiou.

Now, let us compare with this the practice of people more advanced: in Galicia the midwives do not bother about the after-birth, and cases of retention and putrefaction are common; in Persia traction upon the navel-string is frequently practised, so also in Palestine, and if the placenta does not readily approach the orifice, the cord is tied by the aid of a string to the patient's toe and the child is wrapped up and kept warm until the placenta appears; the Chinese follow a similar method, attaching the cord with a string to the patient's hip; in Caledonia it is tied to the patient's toe, as it is thought that the stretching of the foot will then draw out the after-birth. These are the milder and more harmless forms of traction as practised also in the primitive epoch, but among the somewhat more advanced peoples a more forcible *vis a fronte* is commonly resorted to; the manipulations and methods for hastening the expulsion of the after-birth are more dangerous, and more liable to lead to retention. In China death is frequently the result of the forcible dragging out of the placenta by the midwife, whilst inversion and prolapsus are frequent in Russia. The untutored, simple-minded savage, although crude in the methods he pursues, obeys a correct, even if we should term it an animal, instinct, and approximates more closely to the teachings of the science of to-day. Among people of a certain civilization a more harmful method is resorted to—the dragging out of the after-birth by the funis—and the midwives of our great cities either follow the same pernicious habit, or, like the natives of Galicia and such border provinces, leave it in altogether if nature or their own dangerous traction does not readily produce it. The ordinary class of educated midwives of to-day still resort to nauseating drugs; in Russia warm water is given to cause vomiting; in Germany the patient is made to cough, to breathe into the hand; the braided hair of the patient or a finger is placed in her throat by the Greek midwife. In Mexico vomiting is caused to aid expulsion.

Compare with this the simple, effective, and harmless practice of expression which is most common in the intuitive epoch—friction of the abdomen and steady pressure; the Makah Indians even assign this important duty to an especially skilled person, whose special practice is the delivery of the placenta.

Ten lunar months are usually calculated as the period of pregnancy, which is recognized by the suppression of the menses, by the enlargement of the abdomen, and the appearance of reflex neuroses, such as freckles on the face, varying appetite, the flow of saliva, or swelling of the neck. Particular care is taken among many primitive people of the pregnant woman; others prepare more especially for labor, for the easy expulsion of the child: thus upon the isle of Jap, in West Mikronesia, they begin to dilate the os at least one month before delivery is expected; the leaves of a certain plant, tightly rolled, being inserted into the os, distend when moistened by the uterine secretion, after which a thicker roll is introduced, dilating the mouth of the womb to make labor more speedy and less painful.

I cannot detail all the numerous and varying practices, many of which may well serve as a guide at the present day.

In labor proper the greatest effect is achieved by the posture of the patient and by external manipulations. The women of the various tribes and races are delivered according to customs, and in positions, which are peculiar to their people whenever they are free to follow their own instinct. The same woman often assumes various positions in the course of a natural labor: more at her ease in the early stages, she takes the position in which she is confined when the pains become more regular, rapid, and severe; in the last stages of ordinary labor the inclined positions are more frequently resorted to. In all positions, whether the patient is swinging by the limb of a tree, whether she is kneeling by a stake or semi-recumbent in bed, there is a decided change in the axis of the body during the pains and in the interval of rest, and usually the patient has a support of some kind within reach—a rope, a stake, or an assistant—by means of which she can change and intensify the action of the voluntary and involuntary muscles during the pains. In tedious cases, when delivery is retarded and labor will not advance, a change is usually made in the posture of the patient and massage is freely resorted to. A position frequently assumed is the semi-recumbent, seated upon a low stool or upon the lap of an assistant, as it was the custom of the Greeks, as we see it indicated upon the old Peruvian funeral-urn from the time of the Incas, as it is practised alike by some of our Indians, by African tribes, and by villagers in the country districts both in Europe and America. With the advance of the obstetric art the support given the parturient woman by the bone and muscle of her kin, by husband, or by tenedora was replaced by a form of wood;[1] the thighs upon which she sat, the chest against which she rested, were replaced by the cut-out seat and the slanting back of the obstetric chair, which was formed so as to receive the patient in the same position which she was wont to occupy on the lap of a fellow-being. But the support which was given the perineum by the underlying soft part (the lap of the holder) or by a mound of earth or sand when seated upon the ground (as in Africa) was lost with the advent of the obstetric chair. The external manipulations were of the most various kinds: kneading of the abdomen, massage, or shampoo; then simple expression, either by the encircling arms of an assistant or her hands placed upon the abdomen—the most simple and common form of pressure. This living compressor may be replaced by a bandage the ends of which are in the hands of an assistant, or the patient is suspended by a rope and the uterus is stripped down by the weight of an assistant, who hangs upon the abdomen of the sufferer. Truly uncouth is the method of expressing the ovum by a weight placed upon the enlarged abdomen or by the feet of the assistant, who tramples upon the back or belly of the patient. The patient even assists herself by tightening a belt, by leaning with the uterine fundus against a staff firmly placed in the ground, or by

[1] In the seventeenth and eighteenth centuries, even in the beginning of the nineteenth, it was the height of obstetric ambition to devise some improvement in the obstetric chair, and in some countries, as in Turkey and Syria, it is still one of the important factors in labor, a prosperous midwife carrying her own chair from house to house for her patients.

lying upon the floor with a pillow under the abdomen. Then, again, efforts are made to shake out fœtus and placenta, the midwife or assistant raising the patient by her arms and shaking her as she would a sack, allowing her to fall, partially catching her with a shock, so as to force out the uterine contents. In Mexico and Southern India she is shaken several times to promote delivery, but if this does not answer she is rolled upon the ground or suspended by her feet and shaken. The object of this procedure, which is resorted to after the failure of downward pressure, when it is evident that the child cannot be expelled in the natural way, is evidently to throw the fœtus out of the pelvis proper into the roomier upper portion, so that it may change its position and come with head or feet first. The Nez Percé Indians reverse the patient if labor is prolonged, and whilst the head rests upon the ground shake the body vigorously in the air; then they again lead her to the stake and see if the condition of affairs is at all improved; if not, the process is repeated. The Esthonians suspend the patient whilst shaking her vigorously if labor is retarded. In Syria she is packed in a blanket if she is not confined within twenty-four hours after the commencement of labor, and four male or female friends seize its corners, rolling the poor woman about in various directions, occasionally bouncing her up and down to facilitate confinement.

During pregnancy massage and shaking are used to correct supposed malpositions or to produce abortion, as among the Piutes, the natives of Australia, the Loango negroes, and others. Abortion is also inaugurated by firmly kneading and rubbing the abdomen with the hands, or by pounding and working it with the fists, either for criminal purposes or because the often-fatal labors with half-breed children are dreaded. In India and in Africa abortion is often produced when the mother is suckling one infant and finds herself pregnant with another. It is evident that in the primitive epoch abortion is practised to avoid labor at term by which life or health of the mother is endangered.

Massage, kneading, and shaking serve during labor for the correction of malpositions which are supposed to exist if expulsion does not take place in proper time, the same external manipulations being resorted to in the third stage if the placenta does not readily appear. Forgotten by civilization for ages, these practices have only of late years again been accorded the importance which simple-minded primitive peoples have always conceded to them.

B. RELIGIOUS EPOCH.[1]

Of this epoch we have historic record at the time of its highest development only, in early Egypt and India, when it gradually merges into

[1] I have adopted the term "Religious Epoch" for the purpose of characterizing an obstetric practice, purely empirical, in the hands of women, aided in difficult cases by

the third or progressive period with the emancipation of the medical sciences from the temples, as in Greece at the time of Hippocrates. To-day this epoch is exemplified only in its earliest stages, a primitive practice guided by religion, as, for instance, among the Appalachicola Indians, the Bashkirs, and certain of the Arab tribes. Not alone amongst some of our Indians, but amongst other of the uncivilized peoples as well, religious incantations are relied upon to conquer the evil spirit which is rendering the child obstreperous and unwilling to proceed in its passage: the very earliest period of the religious epoch still persists, but the culmination, as represented by the rising power of India and of Egypt, belongs to the past only. The priesthood, the sacrificers to the sun, practised medicine to the exclusion of other castes and assisted in difficult labor. Thus, in Gaul and upon the Britannic isles the Druids, who were priests and legislators, shared exclusively with their women this prerogative.

In Egypt, as recorded by a papyrus still in existence, from a time 3500 B. C.,[1] and in India, as told in the Book of Life, the Ayur Veda, in the period of Brahmanism, 1500 B. C., this epoch was at its height, and obstetric art attained a perfection equal, and even superior in many points, to the later progressive period, in which the physician first appears.

Labor is in the hands of midwives; aid is sought of the priesthood in difficult cases, who in the earlier period beseech divine interference, and in the later actually render effective assistance; surgery and surgical obstetrics being practised and taught by them, external manipulation is resorted to; instruments for the purpose of embryotomy begin to appear; the priesthood, with a certain knowledge of anatomy and of medicine, by manipulations, by internal remedies, more especially cathartic and nauseating, and by mental impressions, overcome many of the difficulties of labor; podalic version is even known; religious laws dictate Cæsarean section upon the dead; and a proper care of the pregnant, and especially of the unclean puerperal, woman; but the death of the child, embryotomy, is the last resort. The abdominal muscles, the *vis a tergo*, aided by the hands of an assistant, are the main agent in the expulsion of child and after-birth.

The religious atmosphere which pervades the medical and obstetric practice in the historic period of this epoch is shown by the innumer-

the priesthood. In the earlier periods of this epoch it is the medicine-man, the devil-seer, or the priest who dispels the evil spirit; but with the progress of knowledge, which emanated from the temple, an obstetric art is developed within the sacred precincts, so that in the more advanced periods medication, manipulation, and surgical operation take the place of prayer and incantation. The next step is the emancipation of the medicating priest from the temple, and we have the perfection of pre-anatomic obstetrics and the physician as consultant.

[1] Haeser: *Grundriss der Geschichte der Medizin*, Jena, 1884.

able deities which were supposed to preside over childbirth, by the combination of religious and medical teaching, and by the appearance of obstetric precepts in religious laws. In Egypt the greatest medical school was in Memphis, with the temple of Imhotep, the Egyptian Æsculapius: medicine was combined with the service of the gods; the sick went to the temple for their physician, and their fee was a gift to the gods. The Greeks had many gods and temples: Æsculapius and his daughter Hygeia were the deities mainly looked to as preservers of health, and innumerable were the pilgrims to their shrine. Roman mythology especially is resplendent in obstetric deities: Lucina is the same as the Greek Eileithyia; we have a Juno and a Diana Lucina, who are supposed to preside over labor, but each separate act and function had its particular deity; the Carmentes Prorsa was called upon in cephalic presentations, and the Post-vorta in malpositions; then we have deities of the puerpera and deities for the infant in its cradle—one for the process of nursing, one for the development of the body, and innumerable others, even to Mena, the goddess of the monthly flow.

The religious teachings of the Israelites touched upon sexual practice, conception, and pregnancy, as was the case in early Mexico. A papyrus now in the Berlin Museum dating back over three thousand years B. C., claiming to be a copy of one still older, records the signs of pregnancy and tells of remedies to further conception. The Zendavesta of Zoroaster indicates the prevalence of religion in the early medical practice of Persia.

Little is known of early Egyptian obstetrics, notwithstanding the wonderful development of other specialties which were properly looked upon as pertinent to medicine. As the medicine of the Israelites sprang from that of Egypt, we have among those people the same religious aspect, and the high regard for cleanliness which is evinced by all Jewish teachings pervades the little that is known of their obstetric practice. The Cæsarean section (Dotze-Joffam) is ordained both upon the dead and living when delivery ceases to be possible; sexual intercourse is limited, and the puerpera guarded. The practice was altogether in the hands of the midwife, the *myelledith*, as she was called by the Jews.

Our most complete knowledge of obstetric practices of this period we owe to the Ayur Veda of India, the Book of Life, the precise date of which is unknown; credited to Brahma himself by some, it is supposed by others to be mainly drawn from Hippocrates. It certainly appears to be a compilation from various sources, written at various times.

A good idea of the presentations of the fœtus exists: ordinary labor is looked upon as a natural mechanism to be cared for by the midwife, whilst the physician skilled in surgery is to be called in difficult cases; eight abnormal positions are described, the fourth of which is with the trunk of the fœtus, side, or back over the os, to remedy which podalic version is recommended; the pushing up of the posterior part and bringing down of the anterior into the os, after which extraction should follow. As the literature of India was but little known, this suggestion is lost, and in later times we hear nothing more of podalic version until mentioned by Celsus and Soranus. The most important cases of dystochia were deformities of the head and pelvis and malposition: cephalic presentations alone were looked upon as normal. The fœtus when dead was cut up if it could not be otherwise removed, and Cæsarean section was at once performed after death in pregnancy. The tardy placenta was removed by pressure, by shaking, and by vomiting. Women of a higher caste were taken to an especial building for their confinement; a separate room and isolation were even accorded those less favored by fortune—a result of that cleanliness which we find instinctively governing in the intuitive practice of primitive periods, and which receives such thorough recognition in the priestly teachings of the religious epoch in India, among the Israelites, and the ancient Mexicans. The puerpera does not leave the house until after the sixth week. The care to be taken of the child is minutely described: the breast is given for six months, then the child is fed on cow's milk, and up to the fifteenth year on rice and milk.

We can hardly wonder at this advanced obstetric teaching when we see laparotomy performed for intussusception, and know that the intestinal suture was practised and rhinoplastic operations were performed.

Notwithstanding the prevalence of religious teaching and the high civilization of India under the sway of Buddhism, I hardly know whether to look upon the obstetric practice of this period as belonging to the religious or to the more advanced epoch: while the caste of the physician and the priest, at first one and the same, remained nearly allied, the surgeon is especially mentioned as a consultant in difficult labor cases. Our knowledge of Jewish medicine is derived from the books of Moses and the Talmud, and whilst the care of the sick devolved upon the priesthood, it gradually fell to the lay members, certain of whom devoted themselves more especially to the study of medicine. So also in Egypt with the high development attained by medicine, which had its origin in the temple, the identity of the physician and priest was soon severed; and Homer already speaks of the physicians of Egypt, saying that the Egyptians are of Pæon's tribe, and every one is a physician; the study of the specialties attained a perfection unequalled until this nineteenth century, but obstetric practice was in the hands of the midwife, and the surgeon was consulted in difficult cases mainly for the purpose of performing embryotomy. In India, in Egypt, and in Greece it was the learning and high culture of the priesthood which led to the development of medical science: gradually a separation was effected, yet the precise period of time cannot be given.

Though this was an epoch little favorable to the development of the obstetric art, great good was accomplished by the intervention of religious laws, as it was possible only in such an era of devotion to the deity. Thus, cleanliness, above all, is preached by the laws of the Jews, the Talmud especially dealing with sexual practices, conception, pregnancy, and labor; and whilst the religious tendency of the art may be traced to Egyptian influence, it was Greek medicine which dictated these correct precepts, as wise and full of forethought as was the law of circumcision. Similar were the teachings in ancient Mexico. Whilst in India medical men became established as a caste separate from that of the priesthood, and in Greece even before the time of Hippocrates the connection between the temple and medical teaching had ceased, the masses still sought relief from the deities in prayer, and this service of Æsculapius continued up to the fifth century after Christ, and still later, carried on by the Christian Church when this took the place of the heathen temple.

The state of affairs was much like that now existing among the lower classes in civilized countries. The attendant upon child-bearing woman—the maea, grandmother, of the Greeks, or mæutriæ, when a professional midwife—was accused of precisely the same failings which we find among that class to-day: she was known to produce abortions, and surpassed her sphere by engaging in the treatment of the sick, especially sick women. Thus we know among others of Aspasia, the midwife mentioned by Aëtius, that she was said to excel in curing disease. In Athens, the midwife, in order to practise her profession, must have had children and herself be past the menopause.

C. THE PROGRESSIVE PRE-ANATOMIC EPOCH.

The practice of midwifery continues unchanged, with but little variation from the time of Hippocrates, in the fourth century before Christ, to the revival of learning in the middle of the sixteenth century, and the teachings of this great master characterize the status of the art throughout that entire time. (The writings of Hippocrates, as now known to us, like the Zendavesta of Zoroaster and the Ayur Veda of Susruta, undoubtedly have not all come from that one great teacher, but we need not here consider the authorship of individual parts, which may be ascribed to his sons, Thessalus and Draco, and his son-in-law Polybus, or even to later times; even Galen complains that the kings of Egypt and Pergamos in the third century B.C. caused much confusion by placing in their libraries such compilations as coming from Hippocrates himself.) In his books, *De Morbis Mulierum* and *De Superfœtatione*, we find most of the obstetric teachings; but in his *Aphorisms* and in other of his writings, which are certainly not genuine, important data are furnished.

The care of childbearing woman is in the hands of the midwife, labor being looked upon as a normal mechanical act: the physician is summoned only after the death of the child for the purpose of destroying and removing it—for the performance of embryotomy. Head presentations are the only natural and hopeful ones: all others are unpromising and must be corrected by cephalic version, whether the child be living or dead. The methods by which this is accomplished are vague—usually external pressure, concussion, and internal remedies which produce vomiting and sneezing. Hippocrates speaks of cephalic version, yet neither he nor those after him give a definite practicable method; hence, whilst advocated in theory, execution was almost impossible, and embryotomy remained the only resort, and the work of the physician was limited to embryotomy and the expulsion of the retarded placenta. The latter is accomplished by slight traction on the cord (far inferior to earlier and more primitive practices). The first obstetric instruments make their appearance, and these are of course those needed by the surgeon for the cutting up of the child: three distinct instruments are described by Hippocrates. The obstetric chair was employed; in more primitive epochs the kneeling and sitting postures were common in childbirth, but in the time of Hippocrates women were confined in bed and in difficult cases on the obstetric chair, which is a refinement of the sitting posture in the lap of an assistant. Labor, as among the most primitive peoples—among our Indians, the Russian mountaineers, and the Chinese of to-day—was supposed to be an effort on the part of the child itself, and any hindrance in its progress was due to its own evil intentions. The pains were explained by expansion of the symphysis, and expulsion was furthered more by irritating pessaries and bloating food and concussion than by the more effective methods of pressure adopted in earlier epochs: with the progress of civilization many of the simple intuitive practices are lost. The one progressive step is the fairer prognosis of footling cases. The sexual organs are well described as far as the eye and hand can reach; the ovaries are not mentioned. A thorough knowledge of the methods of preventing and furthering conception is evinced: the tamponing of the os is described. Malpositions of the uterus and the large fatty abdomen are named among the conditions preventing conception: advice is even given how to produce male or female children. Methods of producing abortion are fully understood—a practice which we find also in the earlier epochs. A separate paper exists upon premature labors in the seventh and eighth months, those in the seventh month being considered the easier and more promising—a belief which continues to the present day as a popular superstition.

Later writers often state that whilst children at the seventh month are viable, those at the eighth month are not.

Better teachings than those found in the works of Hippocrates were impossible with the limited knowledge of anatomy possessed at that time. The Greek religion made progress in this direction impossible, and the customs of the people, as well as the spirit of the times, forbade closer observation of the living woman, thus most effectually checking the development of obstetric art. Podalic version was unknown: cephalic version, in all cases in which the head did not present—that is, in all malpositions—was recommended in theory, whilst its execution in practice was almost impossible with the crude methods known; hence embryotomy remained as the only and last resort in all but simple cephalic presentations—in labor under normal conditions: to this the work of the physician was limited, and for this alone the physician was summoned, if not to remove the tardy placenta. Traction on the cord, the method by which the afterbirth was delivered, is so crude that death from a retained and sloughing placenta must have been common, and it seems but natural that the public withdrew more and more from the male practitioner who brought only death and destruction, with embryotomy for the child and traction upon the cord for the placenta as his only help; thus the opportunities for study upon the living were gradually withdrawn, whilst upon the body of the dead they were impossible.

Such was the status of obstetric art for two thousand years amid the nations of the Western civilization, and for double and triple that period of time among those of the East. Whilst in China and Japan similar practices must have existed long before the time of Hippocrates, no progress is visible, and obstetric art has persisted unchanged from that day until this, yielding in the larger cities only to the scientific practice of our present civilization as carried on by European and American teachers.[1] Hippocrates had carried the art to such perfection as was possible without anatomical knowledge, and suggests much that is valuable which was lost at a later day. We should suppose a certain perception of the origin and importance of puerperal fever from the knowledge of intra-uterine injections and the danger of the cessation of the lochia: many of the reflex neuroses as symptoms and results of pregnancy were recognized; puerperal mania is described by Hippocrates as one of the numerous reflex nervous conditions which this keen observer so clearly describes. The ancients fully appreciated the increased susceptibility of the nervous system of women during pregnancy and in the puerperium; the law in Carthage and in Athens forbade the pursuit and punishment of a criminal or murderer who sought

[1] In 1870 the first school for midwives was established in India.

refuge in the home of a woman who was pregnant or had recently given birth to a child.

The perfection of obstetric art followed in the wake of the most progressive civilization, and thus we find, after the decline of Greek power with Alexander the Great, the most advanced practice again in Egypt, in the school of Alexandria under the Ptolemaici, which retained its prominence almost up to the time of the Christian era: in this school opportunities were afforded for anatomical study, and vivisections were even made upon the bodies of criminals. Herophilus and Demetrius were amongst the most prominent obstetricians of this time, the latter already indicating footling cases as among the least unfavorable of the abnormal presentations. Shortly before the Christian era Greek physicians began to come to Rome, and it was here that the classical teachings of Hippocrates were perpetuated by Celsus (30 B.C. to 14 A.D.) and Soranus (under Trajan, 98 to 117 A.D.), by Galen (131) and Aëtius. For a brief period of time the Alexandrian school stood pre-eminent, until the rising power of Rome created a new and more healthy civilization, which attracted learned men from the decaying monarchies of the East.

A. Cornelius Celsus, a descendant of one of the first families of Rome, though mainly a compiler and following the teachings of Hippocrates, indicates a certain progress in the obstetric art. Like those before and after him, he treats of the obstetric practice as a branch of surgery in that part of his medical writings, "*Quæ manu curet.*" He accepts four positions, head, breech, foot, and shoulder: the assistance to be rendered by the surgeon is version, podalic and cephalic, manual extraction after version, or extraction with the sharp hook and embryotomy; the latter operation is more fully discussed and many instruments are given. Podalic version is mentioned, though, strange to say, only in case of a dead fœtus, and, contrary to Hippocrates, the better prognosis of foot presentations is dwelt upon.

With Celsus obstetric art progressed, but attained such perfection with his follower, Soranus, that it would appear that some prominent workers must have intervened whose writings have been lost, and so it seems from the reference of Soranus to authors of whom we are in total ignorance.

Soranus in his work *Peri Gunaikaion Pathon*, addressed to midwives, records much which has been ascribed to Philumena, Moschion, and Aspasia. The causes of dystochia are in the mother, in the child, and in the sexual organs. In the mother they are physical and psychical; sorrow or joy, peculiar mental conditions, and epilepsy are looked upon as reflex nerve-influences. The physical causes are dyspepsia, anorexia, dyspnœa, diarrhœa, and a fat body. Soranus teaches podalic version to save the living child, though Celsus already says that the feet should be seized if they are near; and upon this slender foundation is based the claim made for him of having practised podalic version, which he advocates only when the fœtus is dead. Soranus is the first in this period to teach podalic version before the death of the child; and if this is impossible, he, like all others, resorts to embryotomy. Both Celsus and Soranus give much space to this, at that time, most important of all obstetric operations.

The teachings of Soranus mark the highest development of the obstetric art in the ancient civilization of the West; fathered by Hippocrates, fostered by Celsus, it was perfected by Soranus, with whom independent original work and progress cease for fifteen centuries. The only credit due later authors to the end of the fifteenth century is the preservation of the greater part of the earlier achievements. Even as the dawn of light approaches, the obstetric chapter in the surgery of Guy de Chauliac depends upon Aëtius, and the teachings of Savonarola are referable to Soranus.

In the *Inaugural Dissertation* of Paul Goerlitz, Berlin, 1873, the work of Soranus is well analyzed, and he is given precedence over all ancient writers for the following reasons:

1. His fair, generally correct, knowledge of the female sexual organs, the separation of uterus and vagina.
2. He anatomically defined the positions of the child.
3. He taught that nature completes normal head and foot presentations, and that breech, knee, and incomplete foot presentations must be converted into complete foot presentations (all previous writers considered only cephalic presentation as normal).
4. He defines the causes of the partus difficilis well.
5. He clearly defines the indications for operative interference. He gives excellent advice as to the position to be occupied by the parturient—in simple cases, on the obstetric chair or in the lap of an assistant; in difficult cases, the recumbent position in bed: expression by pressure on the abdomen is recommended, and dilatation of the os if needed. Most important, and neglected at the present day, are the rules laid down for the hastening of labor or the improvement in the presentation or position of the child by change of posture: the conditions under which the kneeling, the dorsal, or the inclined, or the right or left recumbent position, is to be assumed are precisely indicated.
6. Great stress is laid on internal examination, which is recommended for the detection of malposition and the progress of labor.

The operations described are podalic and cephalic version, extraction by the feet, changing of imperfect to perfect foot presentations, cephalotripsy, embryotomy, and even the accouchement forcé.

It is the influence of Soranus which has extended throughout the Middle Ages. His treatises on the management and feeding of infants, the gymnastic manipulations of the child, the choice of wet-nurse, are most excellent, and more complete than we may find them at the present day. Percussion and succussion are utilized for purposes of establishing a differential diagnosis between molar pregnancy, tympanites, and ascites. The dioptera or vaginal speculum, which is represented upon the papyrus and the obelisks of the Egyptians, is utilized by Soranus in gynecological treatment. Women with broad shoulders and small hips are indicated as liable to difficult labor. He is the first to reject false measures and to limit embryotomy, which was possible, since all abnormal positions were to be changed by version into cephalic or podalic.

Moschion, during the time of Hadrian, 117 to 138 A. D., has written a work for midwives in imitation of Soranus, containing little that is new, though more definite directions are given for terminating podalic presentations, which he, however, says nature can complete.

Claudius Galenus of Pergamos (131–210 A.D.) presents an excellent compilation of the obstetric teaching of that time, and whilst the work of Soranus prevailed throughout Europe until the Middle Ages, the teachings of Galen extended to the Byzantine empire and to Persia, and thus to the Arab conquerors.

The works of the sixth and seventh centuries mainly consist of abstracts and compilations of the teachings of Galen.

Obstetric art, with the sciences, recedes during the gloomy period of the third and fourth centuries, when Roman culture succumbed to luxury, effeminacy, and vice; but, fortunately, with the spread of Christianity the earlier obstetric teachings, with the works of science, were preserved in the convents, which at least retained for the future, if they did not utilize or develop at the time, the teachings of the past.

The collective work of Aëtius, while adding nothing of value, contains many errors not in Soranus; his expression is less clear, his material not so well arranged, and he still follows the erroneous idea of a female pelvis united by yielding bands, whilst he looks upon the male pelvis as a solid structure; and his operative chapters clearly show the retrograde tendency.

The compilations of Paulus of Ægina of the seventh century are well known, but bring nothing new; in the main, he follows Aëtius, and so may be traced to Soranus.

The obstetric art, developed by Hippocrates in Greece, followed the course of civilization to Alexandria, and later to the East and to the West: it was carried by Greek exiles to Persia, and thus reached the Arab conquerors; in the West the rising power of Rome attracted the learned men of Greece. With the Greek physicians the obstetric practice of Hippocrates reached Rome in the first decades of the Christian era, and attained its greatest perfection with Soranus and Galen; after them, with the fall of the Roman empire, came a period of darkness, and art was lost, yet the teachings were preserved in the monasteries of Christian Europe, and buried there.

The practice of the obstetric art was continued by the Arabs, who received their knowledge from Greek physicians who, for the sake of their religion, had fled to Persia: as conquerors of India, the Arabs came into possession of the Ayur Veda, thus adding the treasures of the East to those of the West. Yet obstetric art was not advanced by this warlike and nomadic people: notwithstanding the advantages obtained and the development of the sciences, the teachings received were not even utilized. In Spain and in Sicily in the thirteenth century Arab culture attained its height, and thus the learning of Greece and of India was brought to mediaeval Europe, where Roman knowledge was slumbering in the monasteries, and light was soon to break over the darkness which had so long prevailed.

Among the Arabs obstetric practice was completely controlled by women, by midwives, who even performed embryotomy and decapitation: the treatment of sexual diseases, of women and of men as well, was in the hands of females. Their most prominent medical writers are Serapion, Abul Kasim at the end of the tenth century, Eben Sina (Avesina), 980 to 1037, and Abul Caser, 1120.

The isolation of women and the religious customs of the Arabs were a check to the progress of obstetrics. The teachings of Galen were mainly followed. Version is mentioned in a vague manner, without any explanation as to the method of performing the operation. Footling cases are classified among the abnormal and dangerous, and embryotomy is developed to its fullest extent. The obstetric art of the Arabs is the most deadly and bloody of all: the physician, deprived of every opportunity of observing woman in labor, is summoned only in the moment of extreme peril for the purpose of performing embryotomy. The aid given by the midwife is by the obstetric chair, by innunctions, fumigations, injections, succussion, and remedies which cause sneezing. Concussion, pressure upon the abdomen, and rupture of the membranes are taken from Aëtius.

The obstetric art was not enriched by the Arabs, unless we may consider their numerous embryotomy instruments an improvement, and the many remedies for the purpose of mitigating labor which were brought from the East when the Arabs had learned the use of medicinal plants. On the contrary, the custom, which had been well established by Celsus and Soranus, of summoning the aid of the physician in difficult cases had died out, and obstetric practice was entirely in the hands of women.

During the Middle Ages, after the downfall of Rome, from the sixth to the sixteenth century, darkness prevailed in Europe. Science and art were dissipated by the storms of internal dissension and strife and by the incursion of barbarian hordes from the East: the isolated efforts of struggling knowledge were crushed by the power of the Church, and the clergy zealously retained the gathered learning within their convent-walls as a sceptre with which to sway the masses, which were kept in the darkest ignorance. The teachings of able men were lost or laid aside, and replaced by ridiculous theories and methods which originated in fanaticism and grew upon the ignorance of the people.

This is the most unfortunate period in the history of obstetrics. Complete ignorance prevailed, without the intuitive skill of the primitive epoch, and without the knowledge of the previous civilization: deprived of the aid, however poor, of the male practitioner, the practice of the Middle Ages presents the accumulated evils of previous periods aggravated by ignorance and barbarism.

The fate of childbearing women throughout the European continent was in the hands of the lowest and most ignorant of females. One of the first indications of the coming change was the education of women for the practice of obstetrics in the school of Salerno, and in 1468 Savonarola of Padua gives the first evidence of the return of the physician to the practice of obstetrics, but the midwife continues to operate, and the duties of the physician, when called, are only to medicate; yet the presence of the male practitioner under any circumstances is a beginning. Dancing is mentioned as an aid to labor. Women are confined in a standing or kneeling posture, whilst the midwife presses the abdomen or dilates the parts with the oiled hand. Cephalic version and the possibility of podalic extraction are accorded a few brief passages, which constitute the only mention of these operations for centuries. Yet light is dawning: in the thirteenth century anatomical research begins; one body in five years is allowed and ordered for dissection at the University of Salerno; in the fourteenth century anatomical studies were permitted at Montpelier; in the fifteenth century at the universities of Prague, of Vienna, and of Tübingen. From the Church of Rome came a powerful stimulus to the development of the obstetric art: the penalty of eternal damnation was threatened for the operation of abortion, and Cæsarean section was advocated to replace this accursed proceeding. In the middle of the thirteenth century Bishop Paulus of Meirada in Spain performed Cæsarean section upon a living woman. While the excellent practice taught by Hippocrates and by Soranus was slumbering in convent-walls, a new era was approaching; the foundation for true progress was being laid in the possibilities offered for anatomical study, and in the midst of the deepest darkness the light of modern science was beginning to dawn.

II. Scientific Obstetrics, 1550 to 1888.

The sixteenth century, a period full of historic importance, pregnant with wonderful developments, marks the beginning of a new era in obstetric art, and its development from this time forth is that of an art previously unknown: new discoveries are made, and practices taught centuries ago are rediscovered and perfected by the light of recently-acquired knowledge. The growth of obstetrics is like that of a new art, more healthful for the casting off of pre-existing prejudices. Strange as this may appear, it is a course equally well marked in the rise and progress of gynecology, the speculum, an instrument figured upon Egyptian monuments, described by Roman authors, remaining unknown until rediscovered less than a century ago.

Notwithstanding the importance of skilful aid for childbearing woman, obstetric art developed but slowly, and did not keep pace with other branches of medicine, as it still remained in the hands of empirically-educated midwives, and the surgical features alone received attention, the obstetric work of the medical man being limited to embryotomy; the practice of midwifery was naturally looked upon as a part of the surgeon's art.

The progress of this new-found art and science of obstetrics reveals two well-marked periods: the first is the *period of development*, from the rediscovery of podalic version in 1550 to the beginning of the nineteenth century; the second is the *period of perfection*, continuing to the present time. The period of development is still characterized by the prejudices of previous ages; it is instrumental: abnormal cases only are worthy of recognition, and their management is a part of the surgeon's art. The various steps of progress are marked by the discovery of new instruments or operations: the great surgeons are the obstetric teachers. Not until the present century with the period of progress do we see the complete emancipation from surgery accomplished, and the development and perfection of life-saving methods is the characteristic which now marks progressive steps—the development of non-operative procedures, the study of the physiology of labor, and the prevention of pathological processes.

A. Period of Development—Surgical Period—1550 to 1800.

The most striking feature which distinguishes the scientific from the empirical practice is in the effort toward the preservation of fœtal life, and the three epochs of this first period, that of the development of scientific obstetrics, are marked by the discovery of instruments and methods by which this may be accomplished.

The *first period* is that of podalic version and beginning anatomical study, 1550 to 1647; *the second* commences with the discovery of the forceps, and is characterized by the inauguration of obstetric teaching and obstetric publications; *the third*, which includes the second half of the eighteenth century, from 1745 to 1800, is marked by the perfection of the obstetric forceps, the addition of the pelvic curve, the development of physiological knowledge of the sexual organs, and the induction of premature labor for the purpose of supplanting embryotomy.

First Period: Podalic Version—Pelvic Anatomy.—The spirit of progress which was aroused by the scientific discoveries of the sixteenth century exerted but a tardy influence upon the obstetric art, which continued in the hands of ignorant women. One of the first obstetric publications, that of Eucharius Röslin of Frankfurt-on-the-Main, well characterizes the esteem in which this practice was held: it is a book for midwives, an inferior compilation, entitled *The Rose-Garden of the Pregnant Woman's Nurse*, Worms, 1513, and contains but one indication of progress, a reference to podalic version, showing that the importance of this operation was beginning to be appreciated, which in the year 1550 was for the first time fully described by the great French surgeon Ambroise Paré. Like many other discoveries, it had long been foreshadowed, but to Paré is due the credit of making known to the profession as feasible and successful this most important of all obstetric operations, which was for the child what the discovery of the infectious nature of puerperal fever by Semmelweiss was for the mother, and which laid the foundation for the emancipation of obstetrics from surgery, and thus proved the first step in its development as an independent art. First taught by Paré, the operation was more fully described by his follower Guillemeau. Of almost equal importance were the anatomical labors of Andreas Vesalius, who, in his work *De Corpore Humano*, Basil, 1545–55, gave the first correct description of the normal pelvis. In 1581 the first independent treatise upon the Cæsarean section was published by François Rousset in Paris, although individual cases had previously been reported, and one positively recorded in Italy in the year 1540 by Christopher Bain. Rousset describes ten cases performed by barbers, the patients in several instances being confined repeatedly thereafter, and in one instance the operation was performed in six successive pregnancies upon the same patient.

The opposition of Paré to this operation checked its further development in France, and it disappears for a time from obstetric history, notwithstanding the labors of Aranzi of Bologna, who fairly defines the indications for Cæsarean section in a paper, *De Formato Fœtu*, in which he also touches upon the deformities of the pelvis. A school for midwives was established in the Hôtel Dieu in Paris, and of this the famous Louise Bourgeois was one of the first graduates.

The first impulse to the development of the obstetric art was given in France, and this country continued for a long time the centre of its progress. The position which midwifery took among the medical sciences is well characterized by the fact that its greatest teacher, Paré, was a surgeon: the most important operation, Cæsarean section, was performed by barbers; and one of the ablest practitioners, Louise Bourgeois, was a woman, a midwife of high position, *sage femme* to Marie de Medici, the book in which she publishes her observations being one of the most popular textbooks. Upon the teachings of Paré was based the progress of a hundred years until a new era was inaugurated by the obstetric forceps.

Second Period: The Obstetric Forceps.—From the discovery of the instrument, 1647, to its perfection by the addition of the pelvic curve by Levret, 1745.

The Period of the Straight Forceps.—Whilst the previous century, the most important in the history of civilization, had been marked by the foundation of universities, the discovery of printing, the development of art, we enter now into the philosophic epoch of Bacon and the labors of Sydenham and Harvey, the development of anatomy, and the beginning of physiological study, which exercised a powerful influence upon the course of obstetric art. Whilst tractors of various kinds have been used for the extraction of the fœtus, loops and hooks, such as are still applied to the head by the Chinese, simple catching instruments for the pulling out of the dead fœtus, were the true predecessors of the obstetric forceps, which we must accredit to the Chamberlains—or Chambellans, as they were called before their emigration to England. Dr. William Chamberlain left France in 1569 with other Huguenots during the period of persecution, and with his sons entered upon the practice of his art in England. An energetic, enterprising family, they made good use of the precious secret which they had somehow obtained, growing in wealth and standing: they even entered the political arena, devising wonderful money-making schemes. It was the grandson of the exile, Peter Chamberlain, Jr., who, though a member of the Barber Surgeons' Company, is known by his constant contests with physicians in behalf of the midwives; and his son, Hugh Chamberlain, Sr., born in London in 1630, the best known of the family, after numerous political intrigues was obliged to flee to Holland, where he sold his secret to Roonhuyzen, who behaved so shamefully that it was finally bought from him by the Surgeons' Guild of Amsterdam, and thus became public property. These instruments were flat, broad metallic blades of unequal width covered with leather and without a pelvic curve.

Whilst the obstetric forceps was unquestionably first and most frequently applied by members of the Chambellan—then Chambellaine, Chamberlaine, and finally Chamberlain—family, little credit is given them by the medical profession of the present day on account of the disgraceful way in which they sought to benefit by the secret; and this secret they undoubtedly received from another. The credit is generally given to a Belgian, Jean Palfyn of Courtrai (1650–1730), who himself discovered an instrument which he presented to the Paris Academy in 1721. This consisted of two non-fenestrated blades, nine inches long by twenty-two lines in breadth, of steel, with wooden handles held together by a cloth. The first description was published in Germany by Heister in 1724, who received his instrument from Palfyn, and in England soon after in 1733 by Chapman and Gifford. Improvements were made in 1735 by Dusé, who crossed the handles, by Gregoire of Paris, who fenestrated the blades and added a pin to the lock, and by Chapman, who constructed the first real lock.

The discovery of the obstetric forceps gave a powerful impulse to the development of the art; improved facilities were offered for the instruction of both midwives and physicians by the founding of obstetric schools; the first chair for the obstetric instruction of medical students was established at the Hôtel Dieu in Paris, 1720, and occupied by Gregoire the elder, and in 1743 the first school for midwives, under the same master; the first complete work on obstetrics, based upon scientific principles, was published by François Mauriceau (1637 to 1709) in 1668; and it is well worthy of note that Mauriceau was the first to confine his patients in bed—a bold innovation, as the obstetric chair was looked upon as the only proper place for a confinement *lege artis;* but, like other of the customary methods, the obstetric chair did not yield readily, and retained supremacy until the beginning of the nineteenth century. The deformities of the pelvis were studied by De la Motte in Holland; Roonhuyzen and Deventer assisted in the development of the newly-acquired art: the former had purchased the forceps from the Chamberlains and devised the lever or vectis, about as it has been used until the present day; the latter, originally a goldbeater with mechanical talent, was one of the first to study the deformities of the pelvis. In Germany the most advanced teachings are represented by the publications of Justina Sigmundin, midwife to the court of Brandenburg.

Third Period: Development of the Forceps, and their perfection by the addition of the pelvic curve; limitation of embryotomy by the inauguration of premature labor, 1745 to 1800.

The latter half of the eighteenth century is the culmination of the surgical period, and obstetric art is greatly advanced by the distinguished surgeons of that time, such as Hunter, Levret, Smellie, Roederer, Denman, Stein, Saxtorph, Solayres, and his pupil Baudelocque; but, prominent as practitioners and authors as well, we still find women, the famous midwives Mesdames Lachapelle (1769 to 1821) and Boivin (1773 to 1841).

The results of anatomical and physiological study are beginning to appear, and obstetric practice is modified by the fuller knowledge of the pelvic canal (Smellie) and of the functions of the uterine muscle (Hunter); a most thorough description of the normal and abnormal pelvis is given by André Levret (1703 to 1780), whose most important treatises are upon the pelvic axis and placenta prævia; a result of his anatomical studies was the improvement of the obstetric forceps by the addition of the pelvic curve, which gives a far wider range to its utility, admitting of its application in the higher straits of the pelvis. He also improved the lock, and the instrument as devised by him is the one which still retains supremacy in France, yielding only in extreme cases to the Tarnier axis-traction forceps.

Smellie, in his treatise on the theory and practice of midwifery, 1754, gives the first thoroughly exact obstetric description of the pelvis, with dimensions and measurements of the various diameters, two hundred years after the crude description of Vesalius afforded the first basis for obstetric progress. The influence of physiological study appears in the classical work of William Hunter, whose anatomy of the gravid uterus (1774) was so long unsurpassed. His efforts were directed in opposition to the operative tendencies of the times, which resulted from the perfection of obstetric instruments, and, contrary to most of his contemporaries, he sought to limit instrumental interference, even the application of the forceps, to the most necessary cases; and Thomas Denman continued in the course advocated by his able master, as Baudelocque in France established the physiological teaching of Solayres at a later period.

The beneficent influence of the physiological tendency is also visible in the efforts to replace embryotomy and the dangerous Cæsarean section: the inauguration of premature labor was recommended for the former, symphyseotomy for the latter. The elder Pineau in 1575 theoretically recommended symphyseotomy, but in 1665 it was performed for the first time after sudden death in pregnancy. In 1768 it was again proposed to the Paris Academy by Signault, without receiving attention; finally, in 1777, an operation performed for rachitic deformity of the pelvis called attention to the merits of the procedure, but, though resorted to quite frequently with varying success, the opposition of Baudelocque caused it to disappear completely.

The operation for the induction of premature labor, in thorough accord with the spirit of the times, received the sanction of the best practitioners: it was first advocated at a meeting of London obstetricians in 1756, to whom the procedure had been suggested by the knowledge of the fact that women with a narrow pelvis, who were by chance prematurely confined, bore living children. Macaulay was the first to operate successfully with the definite purpose in view of securing a living child in a case in which embryotomy had been previously necessitated in delivery at term.

François Louis Jos. Solayres de Renhac, in his dissertation published in Paris in 1771, laid the foundation for the coming era in his efforts to found obstetric practice upon the physiology of parturition, the physical conditions of the pelvis, and the mechanical activity of the uterine muscle. Upon the teaching of this French physician the work of Baudelocque was founded, and from this came the modern physiological school of obstetrics.

The earliest German work of this period is that of Heister, which appears merely as a part of his general surgery: to Fried of Strasburg (1689 to 1764) we must trace the beginning of obstetric teaching in that country. In 1751 a school of midwives was established at the Charité in Berlin, and placed in charge of Meckel. In Italy obstetric chairs were established at the University of Florence, 1761; in Milan, 1767; in Naples, 1778. In Dublin, in Edinburgh, and in London obstetric schools had existed since the middle of the eighteenth century.

France still continued as the centre of obstetric development, with ample opportunities for the instruction of both male and female students: the long forceps of Levret were commonly used. In England the shorter instrument of Smellie was almost universal. In Germany the use of the forceps had not yet become so common, and the practice of obstetrics was still more universally in the hands of midwives; yet schools even for their instruction had been but recently established: the forceps used were a modification of the French instrument, and somewhat smaller.

B. PERIOD OF PERFECTION—PHYSIOLOGICAL PERIOD—1801 TO 1888.

The complete emancipation of obstetrics from surgery is at length achieved, and the instrumental tendency naturally resulting from surgical supremacy is yielding to the more rational physiological practice.

The first epoch, from 1801 to 1847, is devoted to the development of the physiological study of obstetrics.

The second, from 1847 to 1870, is marked by the medical progress of the art, the discovery of anæsthesia and of the infectious nature of puerperal fever; finally, in the

Third and last period, from 1871 to 1888, we find the culmination of all previous efforts by the aid of antiseptic practice.

1st. *The Physiological Period, 1801–47.*—Though Péan, Hunter, and others in the eighteenth century had already pointed out the importance of observing Nature's laws in the act of parturition, and had urged that the resort to artificial means be limited to such cases only in which Nature had failed, the possibilities of the recently improved obstetric forceps and the teachings of such masters as Levret and Smellie had carried obstetric practice far on in the course in which it had so long continued as a branch of the surgical art. Then came the sterling publication of Solayres (1771), with the effort to base obstetric practice upon anatomical and physiological laws; but, notwithstanding the continued efforts of Baudelocque, the instrumental, the interfering, obstetrics of Levret and Smellie did not yield to the modern physiological view until after the great changes wrought by the French Revolution, which shook Europe in its foundation; and at that time, with the establishment of the Maternité in Paris in 1798, the modern French school of obstetrics begins.

It is in this period, from the close of the last to the middle of the present century, that the foundation was laid for the practice of the obstetric art as it prevails to-day in its highest development. The obstetric forceps had been generally introduced, and the types then adopted in the various countries persist to the present day, notwithstanding the numerous modifications which have since appeared. Throughout France the forceps of Levret was used—a long steel instrument—and its supremacy has continued to the present day, even serving as a model for the very latest Tarnier forceps, which presents merely the addition of the axis-traction principle. The forceps of Naegele, Bush, and D'Outrepont, also long instruments with a somewhat different lock, prevail in Germany, and have been but little changed, as in England the adherence to the original model of Smellie is evidenced by the survival of the short forceps with a slight pelvic curve, which has of late slowly given way, in part, to Simpson's longer instrument, which is a slight modification of the Vienna forceps. In America preference is given to the native instruments of Hodge and Eliot.

Schools for midwives have been established, and opportunities for the study of obstetrics are afforded to medical students in all the more important universities. The emancipation of obstetrics from surgery is characterized by the labors and writings of independent teachers of obstetrics and by the attempts to render difficult labors less bloody and less dangerous.

During the period of the French Revolution the physiological tendency of obstetric art reached its climax in the École Anti-cæsarienne of Sacombe, a Parisian fanatic, who battled against the Cæsarean operation with all the weapons of the charlatan. He fortunately made no appreciable impression, yet may have exercised some influence upon the restraint which was put upon its execution; the formulating of more careful indications and an improvement in the method of operating were the results of the scientific progress of the period.

The induction of premature labor, which had been first advocated by

English physicians in 1756, was actually resorted to by Denman in Dublin, who records some twenty operations, and by Wenzel in Germany in 1804, who in that country performed the first operation, though it had been suggested by Mai in 1799. Little progress was made by reason of the earnest opposition of Baudelocque, probably under the influence of the Catholic Church in France; and by reason of the continued supremacy of the French school the fate of this proceeding for a time was sealed. Not until practised by Stoltz in Strasburg in 1831 was it again taken up in France, and by the advocacy of Dubois it was finally established, although practised at a much earlier day in dangerous hemorrhage from traumatism or placenta prævia.

Artificial abortion in earlier months now likewise received the attention of scientific obstetricians: this operation, practised both for criminal and economical purposes at all times and in all countries, brought about by primitive peoples by the introduction of dilating vegetable stems into the os uteri, taught by the Greeks as a resort in cases of narrow pelvis, disappeared with Christian civilization, at least as an acknowledged operation, until recommended in England by Cooper in 1717, again by Scheel in Copenhagen in 1799 for the purpose of reducing the mortality of the Cæsarean section; it appears in Germany in 1802 (Mende) and in France in 1835, when it received the sanction of Dubois and Cazeaux. Other attempts were made to replace the Cæsarean section by methods less dangerous: symphyseotomy was proposed by Signault in 1768, and the removal of the entire uterus by Cavallini of Florence in the same year; Michaelis of Marburg made this same suggestion in 1809, as did Blundell of London in 1828; gastro-elytrotomy was advocated by Jörg in 1807, and attempted by Ritgen in 1821; Physick of Philadelphia indicated the same course.

The frequency of pelvic deformities upon the northern coast of Germany led to the more general resort to podalic version, and as early as 1807 we find the combined and external version advocated by Wigand. In part, the preference of the Germans for version was due to the more tardy introduction of the forceps, the real home of which is in France and England; and this preference of the Germans for version as compared with the use of the forceps continues to the present day. The cephalotribe, devised by Baudelocque, was brought to the notice of the French Academy in 1829; the invention of the cranioclast by Sir James Y. Simpson soon followed; and, notwithstanding the present international tendencies of science, the influence of national prejudice is well marked in the still-continuing prevalence of the cephalotribe in France and cranioclast in England, whilst in Germany the former was the more commonly used until partially replaced by the instrument of Braun of Vienna. In America, where the necessity for the use of destructive instruments is fortunately but slight, the cranioclast of Hodge indicates the influence of English obstetrics.

In this period appeared the last of the great midwives, Marie Lachapelle (1769 to 1821) and Marie Boivin (1773 to 1841), like the obstetric chair, relics of a previous epoch which was fast passing away with the perfection of anatomical and physiological knowledge and the development of a thoroughly scientific obstetric practice.

In England an excellent and practical school had been established; the low-forceps operation was popularized; and the judicious teaching of Denman resulted in greater precaution against the carrying of infection and the replacing of the Cæsarean section by the inauguration of premature labor. German obstetricians succeeded in overcoming many of the difficulties of labor caused by pelvic deformities, and from Germany came the first thorough embryological researches, the classical work of Meckel, which appeared in 1812, and the premature labors of Casper Friederich Wolff almost half a century before. The supremacy attained by the French school in medical and obstetric science, due in part to the advantages afforded by the excellent schools and the great hospitals of Paris and the able men there concentrated, was perpetuated by the work of Cruveilhier in pathological anatomy and the anatomical and physiological studies of Bichat.

In the young republic of the Western hemisphere the struggle for existence and material comfort left but little leisure for scientific study, yet such men as Dewees, Meigs, and Hodge, notwithstanding the limited facilities afforded by private practice, have secured an honored place for American obstetrics in the history of medicine.

The discovery of the oxytocic property of ergot is due to John Stearns, president of the Academy of Medicine, who published his observations in the *New York Medical Repository* in 1807.

William P. Dewees (1768 to 1841) first called attention to the dangers of cardiac thrombosis in childbed, though, like other premature discoveries, it was neglected and forgotten until again taught by Rudolph Virchow of Berlin in a period of more advanced pathological knowledge.

Hugh L. Hodge (1788 to 1873) devised the forceps which has been most generally adopted in this country; his craniotomy scissors, compressor cranii, and placental forceps have likewise found general favor.

The English obstetricians of this time are Denman, Ramsbotham of London, his successor Hamilton of Edinburgh, and later Sir James Y. Simpson (1841 to 1870).

The French are, Baudelocque, later Cazeaux and Dubois.

The Germans, Osiander, who suggested the addition of a tractor to the forceps; Wigand of Hamburg (1769 to 1817); Naegele of Heidelberg (1778 to 1851); Bush of Berlin (1788 to 1858); D'Outrepont of Wurtzburg; Siebold, the author of the history of obstetrics; and Michaelis, famed for his studies of the contracted pelvis.

2d. *From the Discovery of Anæsthesia to the Antiseptic Period, 1847 to 1870.*—Anatomical and physical science has been thoroughly developed, and pathological anatomy, together with a more perfect knowledge of embryology, now comes to the aid of the obstetric art. The knowledge of the mechanism of labor has been perfected, the true force of expulsion has been correctly ascribed to the uterine muscle, and abdominal pressure relegated to its appropriate subordinate position. Distinct indications are being established for the various obstetric operations; craniotomy and embryotomy are being gradually limited to their proper sphere: whilst version takes the place of embryotomy in malposition, greater skill in the use of the forceps has reduced the necessity for perforation to the more contracted forms of the pelvis in cephalic presentations.

During this period, from 1847 to 1870, the surgical procedures previously discovered are developed and perfected, and the thorough individualization of obstetric art and its amalgamation with the medical sciences are characterized by a progress which keeps pace with the scientific discoveries of the time. Obstetric operations, favored by the use of anæsthetics, attain the highest possible perfection before the antiseptic period. Little that is actually new appears at this time: the leading features of these two decades are the discovery of anæsthesia by the American dentists Jackson and Morton, and the introduction of chloroform into obstetric practice by Simpson in 1847; the discovery of the infectious nature of puerperal fever by Semmelweiss in 1847, of combined version by Wright of Cincinnati in 1854; and the utilization of external manipulations for placental expression by Crede in 1860.

Dr. Jackson of Boston first used sulphuric ether (1841), which was also tried by Horace Wells, a dentist of Hartford, Connecticut, in 1844, but abandoned for laughing gas; and to Morton, a student of Jackson's, who first used ether in large operations at the instigation of his tutor, is usually given the credit of its introduction. To Sir James Y. Simpson is due the credit of introducing the use of anæsthesia in labor, and in Nov., 1847, he reported to the Edinburgh Medical Society the results of his observation in 50 cases of anæsthesia from the chloroform recently discovered by Bell and Flourens; a most exhaustive work upon the use of ether in childbed was published by Dr. Channing of this country in 1848, and this work of 400 pages, containing these first experiments, has almost exhausted the subject and is still worthy of perusal.

Whilst the new agent was readily received by foreign obstetricians and used to mitigate the suffering of the patient in the more dangerous obstetric operations, it was only in England and America, and more particularly in this country, that it was generally adopted by the profession at large for the relief of pain in ordinary labor. In no other country is the use of ergot and of anaesthesia in childbirth so common as in America, and, whilst with advancing knowledge the application of chloroform is growing more frequent, though its administration is more judicious and more carefully guarded, the administration of ergot is now much less common. The use of this powerful and dangerous drug, which attained a most unpardonable expanse, is being rapidly limited to its proper sphere: developed to a dangerous extent in this period, it became so common that it was given by midwives and nurses, and but few labors were concluded in which ergot was not given by the general practitioner throughout the country; it was relied upon in retarded expulsion of the fœtus and in cases in which the forceps should have been applied.

The most important discovery of the century, however, and the one to which the preservation of more lives is due than to any one surgical procedure, is that of the infectious nature of childbed fever by Semmelweiss in 1847. So highly are the labors of Semmelweiss, who pointed out the dread fiend which gave such terrors to the physiological process of childbirth, regarded, that Schroeder in his work on obstetrics says, and truly, "I believe that wherever the benefactors of mankind are mentioned the name of Semmelweiss should rank pre-eminent;" and, although he at first claimed that puerperal fever was due to infection by cadaveric poison, he gradually enlarged his views, so that our present theories may be based upon his teachings. Notwithstanding the fact that epidemics had been observed at various times, he was the first who positively pointed out the infectious nature of the disease and the most important of the precautions to be observed for the sake of preventing its spread. As assistant physician at one of the Vienna maternities, in charge of two clinics, one devoted to the instruction of midwives, the other to that of medical students, he was struck with the prevalence of puerperal fever in the latter and its comparative absence in the former, and attributed it to the fact that the medical students were engaged in dissections and post-mortem examinations, and thence conveyed the poison, from which the disease developed, to women in labor or recently delivered; and at that early day he took the very precautions to which we now resort: he required the students to use thorough disinfection before entering the obstetric wards. At once the mortality of puerperal women, which hitherto had been 15 per cent., was reduced, and became even less than in those devoted to the instruction of midwives (Parvin). His investigations show that from August, 1784, to December, 1822, during which period the physicians connected with the Vienna clinic performed no autopsies, 71,395 women were confined, with 897 deaths, a mortality of 1.23 per cent. From the 1st of January, 1823, to the 1st of January, 1833, post-mortems were made, and the mortality increased to 5.30 per cent.—28,429 deliveries and 1509 deaths. In the period immediately preceding the advent of Semmelweiss it was as high as 9.92 per cent. After the precautions introduced by Semmelweiss the mortality suddenly dropped to 1.27 per cent., whilst with our present antiseptic methods the mortality in some of the best lying-in hospitals is less than one-half of 1 per cent.

Deadly fevers in childbed connected with cessation of the lochial flow had been observed by Hippocrates and by Galen: epidemics are even recorded at that early day, and again in the Middle Ages. A terrible mortality followed an epidemic of puerperal fever at the Hôtel Dieu in 1664, this epidemic and the increased mortality since that time being attributed to the proximity of surgical cases. The Dublin Maternity was desolated in 1672, as recorded by Thomas Bartholyn, but the epidemic of 1773 was the first one in which efforts were made to investigate the causes. Abundant opportunity was offered for study and observation as the fever swept over the European continent, and more than decimated the lying-in hospitals, the terrible ravages of the disease culminating in the miasmatic plains of Lombardy during the year 1786 in an epidemic from which not a single puerpera recovered. In 1829, 252 deaths are recorded in the Maternité of Paris in 2788 labor cases; in 1831 there were 254 deaths in 2907 cases. Denman proved that puerperal fever could be carried, and that contact with erysipelas, offensive ulcers, and sloughing wounds would produce this deadly disease in the puerperal woman; and his warning was so generally accepted that it was quite customary among English physicians not to go to labor cases after visiting such patients. Again, in 1845, Oliver Wendell Holmes directed the attention of the profession to the true nature of this malady and to the necessary precautions, but, it seems, to no purpose.

Notwithstanding the terrible ravages of the disease in the great maternities, and the correct observations of prominent obstetricians at all times, no further notice was taken of the fact; it was looked upon as a necessary accompaniment of large hospitals, until at last the teachings of Semmelweiss aroused the profession, and even then the full truth was not thoroughly appreciated. But a beginning was made and precautions were taken by more enlightened physicians by which numerous lives were saved, and these epidemics in the lying-in hospitals, though still dangerous, were robbed of their greatest terrors. Not until the introduction of antiseptic practice was this greatest enemy of lying-in women completely overcome.

In 1854, Dr. M. B. Wright of Cincinnati perfected the methods of version by the introduction of the combined method of bimanual podalic version, which he published in a paper on *Difficult Labors and* *their Treatment*, for which he received the gold medal of the American Medical Association. Yet, coming from the American wilds, it was ignored as had been the teachings of Oliver Wendell Holmes, and little heed was given this proceeding, which bears the name of a later discoverer, Braxton Hicks. Though taught by Wigand of Hamburg in 1807, it was completely overlooked, and not even the French translation of Wigand's work thirty years later directed attention to this important procedure. The history of combined version is like that of almost all the earlier methods before the present era of international science—discovered and again forgotten, only to be rediscovered and lost until brought forward at the right moment. So it was left for Braxton Hicks to introduce the combined external and internal version into general obstetric practice by his paper published in the *Lancet* in 1860 and read before the London Obstetric Society in 1863.

Strange as it may seem, this method—the scientific application of manipulations which we find in the earliest primitive epoch—was completely lost and rediscovered as something entirely new in the most advanced era. But so it was with the placental expression of Crede, which he gave to the profession in 1860, and which has borne his name ever since. The kneading of the abdomen with manual pressure on the fundus was a common practice in the primitive epoch; friction and pressure upon the fundus, either by the hands or by the tightening of a belt or a towel, or even by the hands of the patient herself, are the methods resorted to by primitive peoples at the present day, as they were thousands of years ago, and yet English obstetricians claim the discovery of manual expression for the Dublin school, while the Germans accord it to Crede. As a method it will continue to carry the name of Crede, the one who first fully described it as a scientific obstetric procedure.

Nothing seems more natural, yet the history of this practice is the same as that of other of the manipulations common in the earliest epochs, which have been lost or have yielded to a much less rational method in the darkness of beginning knowledge. For instance, the placental expression of the intuitive practice yielded to traction on the cord, which is the most common resort of midwives at the present day, and an incarcerated placenta, due to a tearing of the cord, is still not uncommon in the practice of midwives and even physicians. Strange as it may seem, in this advanced era of scientific medicine it is the progressive obstetrician only who appreciates and utilizes the intuitive practices of the earliest epoch.

Among the English obstetricians we may mention: Matthews Duncan, McClintock, Leishman, Churchill, Braxton Hicks, and Barnes; among the French, Depaul and Pajot; among the German, Scanzoni, Crede, Martin, Spiegelberg, and Braun; in America, G. S. Bedford, William H. Byford, Penrose, Isaac E. Taylor, Fordyce Barker, Albert H. Smith, and Ellwood Wilson.

III. The Antiseptic Period, 1870 to 1888.

This period will be for ever characterized in the history of midwifery by the introduction of antiseptic practice into the obstetric art, and by the almost complete disappearance of puerperal fever from the great lying-in hospitals; by the introduction of the Tarnier forceps, which has resulted in the perfection of the high-forceps operation and more general application of the axis-traction principle; and, finally, by the almost ideal perfection attained by the Cæsarean section, which, with a mortality of but 17 per cent., is established as one of the acknowledged obstetric operations, even promising to replace the artificial induction of abortion and premature labor.

The *first decade* of this period, from 1870 to 1880, is that of active antiseptic midwifery, of intra-uterine injections, the destruction of the poison by germicides, mainly carbolic acid; whilst the

Second, the present decade, from 1880 to 1888, may be called the aseptic period, the prophylactic period, the period of prevention. The nature of the dangerous poison has been revealed by Pasteur, by Tarnier and Koch, and we no longer battle with the established disease, but seek to prevent its development, to guard against the threatening danger. The first decade is that of antisepsis; the second, that of asepsis or prophylaxis. The most important innovations during this period, in their chronological order, are as follows:

The revival of symphyseotomy in Italy by Morisani and Novi of Naples: in cases with a conjugata vera less than 6.7 cm., or $2\frac{5}{8}$ inches (Parvin-Harris), from 1866 to 1881, 43 women and 42 children were saved by 53 operations, the pubic joint being divided by a small, sickle-shaped, probe-pointed knife (the falcetta of Galbiati).

1870. First application of the principle of antisepsis by Prof. Stadtfeldt in the Copenhagen maternity by the use of carbolized 2 per cent. vaginal injections; thorough disinfection of the medical personnel; washing of hands in $2\frac{1}{2}$ per cent. solution; 10 per cent. carbolized oil as a lubricant; injections every two hours during labor; during the puerperium bathing of the genitalia two or three times a day with carbolized water; intra-uterine injections of 3, 4, and 5 per cent. solutions being reserved for operative cases and the retention of membranous débris.

Spiegelberg urges the importance of the early performance of craniotomy, presenting his own experience, 3 deaths in 33 cases from 1870 to 1877, contrasted with 13 cases and 7 deaths as the result of a more expectant plan and tardy operation, as practised from 1865 to 1870.

1871. Among the various methods advocated for the preservation of the perineum to take the place of the universal and frequently injurious and antiquated practice known as the support of the perineum, the hand pressing the perineum and the head against the symphysis, is that of Goodell, the holding back of the head by placing the thumb against the occiput, at the same time drawing forward the perineum by one or two fingers hooked in the rectum.

1874. First correct and complete macroscopic and microscopic description of the uterine decidua and the development of fœtal and maternal tissues toward the formation of the placenta by Kundrat of Vienna and Engelmann of St. Louis: the placenta is formed by the growth of the decidua serotina toward and into the villi of the chorion. The development of the decidua, the method of its expulsion and new growth, are described as now generally accepted with but few variations, which were presented by Leopold of Leipzig two years later.

1875. Prophylactic, antiseptic measures first introduced in lying-in wards by Bischoff in Switzerland.

1876. Gastro-elytrotomy proposed by Gaillard Thomas of New York as a more safe and conservative method to replace Cæsarean section, which had hitherto been so unsuccessful. The method was published after a successful operation by Dr. Skene of Brooklyn. The first operation performed by Thomas in 1870 resulted fatally to mother and child.

1876. Prof. Porro of Pavia first performed the operation known by his name, though he had already suggested in 1874 the removal of the uterus and its appendages, after extraction of the child, as a substitute for Cæsarean section in cases of contracted pelvis.

1876. Intra-uterine injections of hot water, 122° to 129° Fahr., 50° to 54° C., recommended by Emmet in gynecological cases, first used upon a larger scale in lying-in hospitals as a hæmostatic for the purpose of controlling post-partum hemorrhage.

1876. The use of gynecological instruments advocated for the purpose of facilitating obstetric operations by Dr. Skene of Brooklyn.

1876. Viburnum prunifolium, a popular remedy in the Southern States, suggested as a uterine sedative for the purpose of preventing threatened abortion by Dr. Jenks of Detroit. Its antiabortive qualities had been previously noted by Dr. Phare of Mississippi, and were known to Southern physicians.

1876. Active antiseptic practice at its height; prophylactic intra-uterine injections frequently made. Prof. Winckel of Dresden calls attention to the danger of this practice.

1877. First model of the axis-traction forceps presented to the Paris Academy by Prof. Tarnier.

1878. Prof. Müller of Bern modifies the Porro operation by prolonging the abdominal incision from the symphysis to two fingers' breadth below the umbilicus, by raising the uterus out of the abdomen, and by contracting the cervix by the elastic ligature before making the uterine incision—a practice which has been generally adopted under the name of the Porro-Müller operation.

1879. Dangers of intra-uterine injection shown by Veit of Bonn by 10 serious accidents in 400 injections.

1880. Hoffmeier and Runge of Berlin clearly demonstrated the uselessness and danger of prophylactic post-partum injections, as advocated by Schulein and Richter.

The efforts of Schroeder and Gusserow, of Winckel and Breisky, in behalf of the new movement toward cleanliness and asepsis served greatly to check the progress of officious over-active antisepsis.

1880. Credé applies the antiseptic method for the prevention of ophthalmia neonatorum by the instillation into the eye of a single drop of nitrate-of-silver solution, 1 : 50. In 1879 he had employed vaginal douches of 2 per cent. carbolized or salicylated solution in all women suffering from vaginitis who presented themselves at the Leipzig Maternity; though the cases of ophthalmia neonatorum diminished, they did not cease. He then used an instillation of borax, 1 : 60. The desired result was still not achieved, and injections of nitrate of silver, 1 : 40, caused too great an irritation; but, notwithstanding the class of cases received at a lying-in hospital, ophthalmia neonatorum is now completely eradicated by the introduction of the practice of Credé in all larger maternities. A single drop of a solution of nitrate of silver, 1 : 50, is instilled into the eye immediately after birth, and for twenty-four hours thereafter a compress soaked in a solution of salicylic acid, 2 per cent., is applied to the eyelids. The frequency of the disease, previously from 7 to 13 per cent., is now almost zero.

1880. Dohrn introduces a dry antiseptic dressing over the umbilical wound to prevent the transport of germs and to hasten desiccation. A dressing of carbolized wadding is applied to the umbilical region after a thorough washing with a $2\frac{1}{2}$ per cent. carbolized solution. We have a repetition of one of the most primitive methods, antisepsis and desiccation by fire, as recorded in the practice of the intuitive epoch.

Great improvements are made in the methods of treating the asphyxia of the newborn child: the dangerous and very common practice of blowing air into its lungs, which succeeded in forcing the mucus or liquor amnii, most usually the cause of the asphyxia, well into the bronchi, has given way to the cleansing of the bronchial tubes by the removal of the obstructing fluids by suction; and now the perfected methods of inducing artificial respiration were applied for the resuscitation of the asphyxiated child by Behm, Schultze, and Schuller, bringing into play especially the diaphragm and the thoracic muscles by movements of the arms and legs.

In European clinics the use of ergot during labor has completely disappeared, and the giving of the drug is restricted to the uterus after expulsion of its contents. In America this practice is now slowly gaining ground.

1881. The bichloride of mercury was introduced by Tarnier, and its use, as recommended by him, in solutions of 1 : 2000 and 1 : 4000, was rapidly adopted in all countries.

1882. Garrigues successfully employs the faradic current for the destruction of the fœtus in extra-uterine gestation, one electrode being placed in contact with the tumor in the vagina, the other upon the abdomen over the uterine fundus, the current being gradually increased to such intensity as could be borne by the patient without suffering.

The antiseptic pad for the reception of the lochial discharge in place of the old-time napkin recommended by Richardson of Boston and Garrigues of Brooklyn.

1885. Bayer of Strasburg recommended galvanism as an agent for the purpose of exciting the induction of premature labor, but as the method seemed to possess no marked advantage over the more simple practices in general use, it received but little attention.

1886. The use of the faradic current in labor is recommended by Engelmann, in the first stage, in weakness and irregularity of labor-pains, to relieve pain and regulate the contractions; later, to stimulate the traction of the uterine muscle; in post-partum hemorrhage, as a hæmostatic equal to the hot douche or the perchloride of iron; and during the puerperium, for the purpose of overcoming subinvolution and the paralysis of urethra and bladder so annoying in the first days of childbed after difficult labor.

1886. The correctness of the theory of maternal impressions demonstrated by Fordyce Barker of New York in his paper before the American Gynecological Society. The possibility of this occurrence, so long one of the myths of obstetric science, has at last been proven as a positive fact.

1887. An international obstetric nomenclature, as suggested by Prof. Simpson of Edinburgh as chairman of the committee, was adopted by the Tenth International Medical Congress in its meeting at Washington.

1887. Hypnotism is used in Paris and Vienna in isolated cases to mitigate the pains of labor.

The most striking feature of this period is undoubtedly the introduction of antiseptic practice, the development of the high-forceps operation as a sequence of the axis-traction instrument of Tarnier, and the wonderful results of the Cæsarean section.

Notwithstanding that Semmelweiss in 1847 had so clearly indicated the true nature of the dangers which threaten puerperal women, and had practically demonstrated the possibility of prevention, the mortality in the wards of the great lying-in hospitals continued as great as ever before. Puerperal fever was looked upon as a necessary result of large institutions, and at that time safety was supposed to consist in confinement at the home of the patient. It was Lister who utilized the scientific researches of Pasteur and made the practical application from which sprang the rapid growth of antiseptic surgery. But the labors of Tarnier, who sought to benefit obstetric science by the new discovery, passed unheeded, and not until Stadtfeldt of Copenhagen practically applied the method upon a larger scale did antiseptic practice enter into the science of obstetrics. Its advantages once demonstrated, German obstetricians were quick to follow, and proved its most enthusiastic advocates. Carbolic acid was the antiseptic most generally employed and constantly applied—vaginal injections before labor, in many of the lying-in institutions the spray during labor, and prophylactic vaginal and intra-uterine injections after its completion. This abuse of antiseptics was followed by evil results, partially the effect of the remedy itself, carbolic acid, partially a mechanical injury: the chill which was often observed after the intra-uterine injection of carbolic acid must be ascribed to that agent, since it does not follow if corrosive sublimate is substituted.

The enthusiasm for the new antiseptic method led to an abuse which was followed by serious results. Veit of Bonn in 1879 recorded 10 deaths in 400 injections, but it was especially Runge and Hoffmeier of Berlin who called attention to the dangers of this abuse. Guided by the progress of the antiseptic methods in surgery, Winckel, Breisky, Schroeder, and Gusserow inaugurated a new departure, the result of which is the present aseptic or prophylactic method, based upon the belief that infection is guarded against most safely by preventing the introduction of poisonous matter; hence the war should be directed against the possible carriers of infection—the obstetrician himself, his instruments, and attendants. The dangers of carbolic acid, together with the annoyances accompanying its use, the odor, and the greater quantity necessary, caused the ready reception of the corrosive sublimate recommended by Tarnier in 1881; and his is the method now generally practised in all the larger lying-in institutions—the most thorough prophylaxis, absolute cleanliness of room and bed; vaginal injections before labor and washing of the parts with a solution of 1 : 2000; perfect cleansing of the parts after labor with the same solution, and the reception of the lochial discharge in pads of an antiseptic material, oakum or cotton, which can be thrown away or burned as soon as saturated. Unless necessitated by unusual causes, the hand is not introduced, and Credé's method is resorted to for the removal of the placenta. The expectant plan, as now advocated by Credé, has come into general use, both as being in itself the most satisfactory and safe, and by causing the expulsion of a tardy placenta by external pressure, avoiding the necessity of introducing the hand.

The most important of all antiseptic precautions is the cleanliness and perfect asepsis of the attendants, and especially of their hands; in this centres the advanced asepsis of the present day both in obstetrics and in surgery: a thorough scrubbing of the hands with brush and soap, followed by a washing in the bichloride solution of 1 : 1000; all instruments used are placed in the same solution. For intrauterine injections a solution of 1 : 4000 is preferred, as the toxic effects of mercury frequently appeared in the earlier practice with a solution of 1 : 2000; but careful observation of the individual patient is necessary even if the weaker solution of 1 : 4000 is used, as idiosyncrasies are frequent. In the Charité, for instance, poisoning by corrosive sublimate was observed in 9 out of 35 cases in whom vaginal injections of eight liters daily were used of a solution of 1 : 4000. If lubricants are used, glycerin of vaseline with carbolic acid or corrosive sublimate is preferable, but for ordinary examinations it is best to insert the finger still moist with the antiseptic solution.

The recent tables of Bar show a mortality in the Maternité of Paris varying between 7 and 20 per cent. from 1860 to 1870, where now a mortality of but $1\frac{1}{10}$ per cent. is found. In the Prague maternity it is $\frac{36}{100}$ per cent., 11 cases in 3010 in 1879, fluctuating in the various lying-in institutions during the first decade of the antiseptic period from 1870 to 1880, between $\frac{1}{2}$ per cent. in the smaller ones in which antiseptics had been introduced, and 2 per cent. in the Paris Maternité, whilst with the present system of prophylactic antisepsis it has been excluded almost completely, so that we see but a few isolated cases.

Leopold records[1] in 1686 labors from May, 1885, to May, 1886, not a single death from infection; in 1403 labors from May, 1886, to May, 1887, not a single infection; and we must remember that this is in a lying-in hospital, where numerous cases of deformity of the pelvis occur and operations are frequent; although not so frequent as, for instance, in the clinic and polyclinic of Halle, where in 1553 labors we find a record of 694 forceps cases, 351 versions, 195 podalic extractions, 29 craniotomies, 5 embryotomies—82 per cent. of operative cases.

The Cæsarean Section.—Strange as it may seem, notwithstanding the wonderful progress of surgery, the Cæsarean section remained a dangerous, almost necessarily fatal, last resort until within the last

[1] *Deutsche medicinische Wochenschrift*, 1887, vol. xiii. 25.

ten years—equally fatal in the hands of the modern surgeon and of the Buddhist priest, as it had been in the Middle Ages, as it was among the negroes of Africa; hence it was but natural that other means should be looked for. Symphyseotomy, though practised with remarkable success in Italy by Morisani and Novi of Naples, saving 43 mothers and 42 children in 53 operations, was not received with favor by the profession: gastro-elytrotomy, earnestly recommended by Thomas in 1876, likewise found but few imitators. Proposed by Jörg in 1806, attempted by Ritgen with fatal result in 1820, suggested by Physick in 1822, again proposed by Baudelocque in 1823, and performed with fatal result by Thomas and Skene, it was not until after the first successful case by Skene of Brooklyn that Thomas ventured to propose this method in place of the old Cæsarean section; the results achieved were no better, and, moreover, the danger of wounding the ureters or bladder, and the long suppuration of the vagino-abdominal wound which followed, proved a serious obstacle to its success. The operation proposed and successfully performed by Porro in 1876 seemed to satisfy the profession, which had been long in search of a less dangerous substitute for the Cæsarean section, and it was generally accepted; improved by Müller of Bern in 1878, it received the sanction of the Vienna school, and for a time completely displaced the Cæsarean section. The indefatigable labors of Harris of Philadelphia in behalf of the classical operation had served to keep the Cæsarean section before the profession, and it was due to the efforts of Saenger of Leipzig, who looked upon this as a conservative method in comparison with that of Porro, that the old operation was again given a trial; and by the method suggested by Saenger, and first practised by Leopold, the results achieved were equal and superior to that of the Porro-Müller operation; 150 cases of the Porro operation presented a mortality of 54 per cent. to the 40 per cent. in 40 cases of Saenger's conservative operation. Later statistics show but a mortality of 25 per cent. in 58 cases, so that the question now arises whether craniotomy in case of a living child should not give place to this operation.

Crede, in his latest paper urging the conservative Cæsarean section in place of perforation, states that the latest statistics show a mortality of 8.4 per cent. in cases of perforation and 17.5 in Cæsarean section, and adds that in the latest cases operated on in Dresden and Leipzig by himself, Saenger, and Leopold, the maternal mortality in Cæsarean section has been reduced to 5 per cent.; yet such advances have been made in craniotomy that a successful operation is now possible in a conjugata vera of but $3\frac{1}{2}$ cm., and judgment must be withheld until this operation has been perfected and tested with all antiseptic precautions.

The temporary success of the Porro operation was due to the fact of its introduction in the first period of successful antiseptic laparotomy.

But it has now taken its proper place: in those cases in which hemorrhage is especially to be feared, the old Cæsarean section is decidedly preferable, as bleeding is thus best controlled, whilst if sepsis threatens the Porro operation offers the most favorable prognosis. But under certain circumstances, disease of the cervix, carcinoma, or fibroid tumors, it is contraindicated.

Heretofore, craniotomy has been deemed advisable in deformity of the pelvis with uniform contraction and a conjugata vera of from 8 cm. to 6½ cm., whilst in the pelvis with antero-posterior contraction, the flat pelvis, it was confined to a conjugata vera of 6½ to 5, and even 4, cm. Less attention has been paid to this operation of late, whilst the Cæsarean section has attained a wonderful development; hence the temporary predominance of the latter. Undoubtedly, with a proper application of antiseptic methods to embryotomy the mortality of this operation will be reduced. Nevertheless, the possibility of preserving fœtal life will lead to the adoption of the Cæsarean section in lying-in institutions, at least in those cases in which heretofore craniotomy has been performed, and the indications for the Cæsarean section will no longer be limited by a conjugate diameter of less than 4 or 5 cm.

The Axis-Traction Forceps.—It was to the French school, again, that we owe the introduction of this new forceps; it was from France that the forceps originally came; it was in France that the pelvic curve was added; and from France comes the new axis-traction instrument. The idea was not a new one: suggested by leather straps or towels attached to the lock, as indicated by Osiander, traction apparatuses were recommended by Herman in 1844, by Hubert in 1860, by Hartman in 1870, also by Moralis and Joulin, but it seems as if obstetricians had not been ready for the new departure, being still occupied with the perfection of the low-forceps operation. The instrument introduced by Tarnier in 1877 was the long French forceps with a tractor attached to the blades, an exaggerated pelvic curve, and a perineal curve. In England and America the idea was readily accepted, and modifications of the instrument soon appeared, the best of which are the forceps of Lusk of New York and of Simpson of Edinburgh, who merely added the tractor to the forceps of his uncle, Sir James Y. Simpson. Tarnier himself repeatedly modified his instrument, until it has of late again appeared in the form of the old Levret forceps without the exaggerated pelvic curve, with the addition of the tractor attached to the blades. In Germany the instrument found no favor, as the operation of version is preferred in those cases of somewhat contracted pelvis in which the high operation may be demanded.

The highest tribute is paid to the Tarnier forceps by Braun of Vienna, who testifies to the fact that in France the forceps operation is more fully developed than in Germany, and the obstetrician succeeds in the delivery of a living child in cases of such contraction where craniotomy is often resorted to in Germany.

The instrument invented by Breuss of Vienna, with a joint in the blade, has proven of no especial service.

Conclusion.

Obstetric art has attained a most wonderful development during the last decade: this branch of medicine, being completely liberated from the confining bonds of surgery, and having attained full recognition as a distinct department of medicine, has advanced step by step with the progress of science. The use of anæsthetics for the purpose of mitigating the pangs of normal labor, long customary in America, is gaining ground abroad; the administration of ergot is confined to the uterus post-partum; the hot douche and the electric current have replaced more dangerous hæmostatics. The Cæsarean section has become an established, fairly safe operation, and promises to replace, in part at least, that fatal relic of the bloody period of surgical obstetrics, embryotomy; and the high-forceps operation, which followed in the wake of the axis-traction instrument, encroaches upon the sphere hitherto retained by craniotomy. Puerperal fever has been banished from lying-in institutions, which hitherto have been its breeding-place, epidemics have ceased, and sporadic cases only appear now and then.

The introduction of the prophylactic method has wrought a marvellous change in obstetric practice, which is well characterized by a comparison of results: in the New York Maternity, in 429 cases from 1882 to 1883, a mortality of 6 per cent. is noted; after the reform inaugurated by Garrigues we find a mortality of only 0.21 per cent. in 483 cases from 1885 to 1886. In the large clinics of Vienna, utilized freely by students and midwives, we find a mortality of .4 per cent.; in the Charité in Berlin in 1885 only 12 cases of puerperal fever in 1368 labors, .35 per cent., and 4 of these are readily accounted for, as one patient came into the house infected and a careless midwife carried the infection from this one patient to three others.

Leopold in Dresden had but 4 cases of infection occurring in the house in the course of two and a half years in 3196 labors, .012 per cent., and from May 1, 1886, to May 1, 1887, not a single one; moreover, during this year the patients there confined, after all operations, showed no elevation of temperature with the exception of 12.8 per cent. of the cases, which for one day indicated a rise of half a degree C.

Garrigues, in his *Antiseptic Midwifery*, tells us that by the antiseptic treatment of the nipples, and by compression in threatening cases, mastitis has entirely disappeared from the Maternity Hospital.

Tetanus neonatorum has almost ceased with the antiseptic treatment of the umbilical wound, and the purulent ophthalmia which has proved so destructive, and which seemed to be a necessary accompaniment of lying-in institutions, is eradicated by the simple proceeding of Credé.

This is certainly a most remarkable result, indicating to the thoughtful obstetrician the perfection to which his art may be carried.

But such results give rise to most uncomfortable reflections: such is the perfection of obstetric art in the hands of the masters of the art and in lying-in institutions, whilst in private practice, in the homes of comfort with the attendance of the best practitioners and the care of good nurses, many a young mother yields her life to the dangers which still accompany home confinement. We are told that the records of a prominent life-insurance company reveal a mortality of 17 per cent.[1] in private practice, and that is among the better classes. In the hospital all operations, including the most dangerous, are performed with scarce a rise of temperature; notwithstanding the gathering of patients from the poorest and filthiest surroundings, the proximity of surgical wards and medical cases of all kinds, puerperal fever is almost unknown. The hospital has become the place of greatest safety for the lying-in woman, whilst in her home she is still exposed to many of the dangers of parturition.

Why is this so?

First and foremost, it is the neglect of prophylaxis and of the necessary antiseptic precautions in private practice, by which the life of the parturient is endangered. The dangers of the hospital are evident, and have been overcome, but those which lurk in the home are more occult, and hence are ignored; the same care, the same cleanliness, should be exercised in hospital and residence. The introduction of the perfected prophylactic methods into private practice will prove the crowning glory of modern physiological obstetrics, and will at once reduce the fearful mortality of physiological labor to an imperceptible percentage. But there are other causes also.

The attention of the scientific obstetrician has been given wholly to abnormal labor, and the management of all such cases has been perfected to the utmost, whilst the care of normal labor, as it occurs in the great majority of private cases, is neglected. The parturient suffers under the continuance of the old prejudice that labor is a physiological act and should remain under the care of the midwife, whilst the physician sees only the pathological cases. In the hospital he controls them all, and hence the good results. Notwithstanding the excellent example of the control of natural labor by the medical man set by American practice, and now gradually received in the older countries, the practice of centuries and tens of centuries still remains firmly rooted among most peoples, and even in Germany, where

[1] Extensive investigation has shown the mortality of confinement cases in general practice to be about 1 per cent.—[Ed.]

surgical obstetrics has attained its utmost development, normal labor is still controlled by the midwife; if the physician is called, he does not seek to guide its course, but holds himself in readiness to interfere with the advent of pathological complications: he remains an idle spectator during the progress of normal labor. The unfortunate termination of these so-called normal labors is due in part to this prejudice and in part to the defective obstetric instruction in our schools.

Serious injuries, if not fatal results, most frequently follow the so-called normal labors in private practice. Whilst the management of pathological labor has attained such perfection as to render almost any, even the most desperate, case promising in the hands of able obstetricians, so little attention has been paid to the correct guidance of what is termed normal labor that the terrors of childbed have been but little mitigated for the young mother confined in her home, even when under the most fortunate circumstances.

In Germany and France the facilities for instruction are abundant; in England and America they are but scant. In England the young physician is given a diploma and admitted to practice after a three months' course in midwifery (Simpson). Whilst theoretical teaching is all that can be desired in the United States, practical instruction is but limited, notwithstanding the noble efforts of James P. White, the pioneer in obstetric teaching, who braved the wrath of his colleagues and his fellow-citizens when he established the first obstetric clinic in the United States in his home in Buffalo, N. Y. The student is taught the management of pathological cases, but how to guard his patient against their occurrence, the practical management of simple labor, examination, and manipulation, he must learn by experience; and not until the proper guidance in normal labor, a physiological, prophylactic, and antiseptic obstetrics, is thoroughly taught, practically and theoretically, will the results of private obstetric practice equal those of the hospital, which are far better under circumstances far worse.

The efforts of the obstetric teacher must now be directed to practical instruction in the lying-in room, to the perfection of the management of normal labor, and the introduction of antiseptic methods into private practice as they have been received in the hospital.

TABULAR VIEW OF THE HISTORY OF OBSTETRICS.

I. Empirical Obstetrics.

Obstetric practice in the hands of women; disregard of fœtal life; ignorance of anatomy and physiology; the cephalic presentation the only hopeful one; labor is supposed to be a voluntary act on the part of the child, and the abdominal muscles are the propelling power.

a. Primitive or Intuitive Epoch.	The obstetric practice of primitive peoples from prehistoric times to the present day.	Assistance, if any, rendered by women, by neighbors and friends; the efforts of nature furthered by varying posture of the patient, by massage and pressure and nauseating internal remedies; forcible expulsion by abdominal pressure in support of the natural *vis a tergo* is the last resort.
b. Religious Epoch.	The obstetric practice of the semi civilized nations of the present day most fully developed in the earlier periods of India, Egypt, and Greece; terminating in Greece 400 B.C.	Assistance rendered by women; empirically-educated midwives appear; in difficult labors the priesthood is appealed to, who give spiritual (Arabs, Florida Indians, Bashkirs) or mechanical aid (early period of Egypt and of Greece). The practice is similar to that of the Intuitive Epoch: pressure and external manipulations in support of the natural *vis a tergo;* internal medication by purgatives and vomitants; excellent obstetric precepts are given in religious laws and customs; the presentations are diagnosed; cephalic presentations alone are hopeful; instruments for the destruction of the fœtus appear.
c. Advanced Pre-anatomic Epoch.	400 B.C. to 1550 A.D., the status of obstetric art in India and in Egypt, when at the height of their civilization, in Greece after Hippocrates, carried by the Arabs to the East and to the West, continuing in Europe to the middle of the sixteenth century, persisting at the present day in China and Japan.	Obstetric practice in the hands of women; the aid of medical men sought in difficult cases; an external anatomical knowledge of the pelvis is obtained. Cephalic presentations alone are hopeful; cephalic version is attempted; embryotomy is the last resort. Intuitive manipulations disappear; the obstetric chair and numerous instruments for the destruction of the child are devised; the work of the medical practitioner is altogether surgical, as he is not called until after the death of the child; and obstetric art is taught as a branch of surgery.

II. Scientific Obstetrics.

Obstetric practice in the hands of the physician; the obstetric art accepted as an independent branch of the medical sciences, distinct from surgery; scientific development of the art upon an anatomical and physiological foundation; preservation of fœtal life a fundamental principle.

1550–1800. *a. Period of Development. — Surgical Period.* Prevalence of early surgical influence.	From the discovery of— 1. Podalic Version, 1550-1647, to the introduction of the forceps.	Rediscovery of podalic version by Paré, 1550; anatomy of the pelvis described by Vesalius, 1543; Cæsarean section performed by Rousset, in Paris, 1581; *Midwifery* of Louise Bourgeois published, 1609; circulation of the blood discovered by Harvey, 1628; beginning of anatomical research
	From the introduction of the— 2. Forceps, 1647–1754, to their perfection by the pelvic curve.	Introduction of the straight forceps by Chamberlaine, 1647; first *Midwifery* published by Mauriceau, 1668; first obstetric chair established in the Hôtel Dieu in Paris by Gregoire, 1720; discovery of the forceps by Palfyn, 1721. 1753, the instrument of Roonhuyzen made public property; the lever devised by Roonhuyzen; obstetric chairs established in all large schools, first in England and France, later in Germany.
	3. 1754–1800. Perfection of the forceps to the beginning of the Physiological Epoch.	1751, pelvic curve given to the forceps by Levret. 1751, mechanism of labor described, and the first correct measurements of the pelvis made by Smellie. 1756, inauguration of premature labor suggested to replace Cæsarean section and craniotomy; carried out in England, 1768. Symphyseotomy performed, 1777; Hunter and Boerhaave inaugurate the physiological study of labor, 1768; Casp. Fried. Wolff, first embryological study. 1771, appearance of Solayres' physiology of parturition; beginning of modern obstetric principles the observation of nature, and resort to artificial means only if nature fails.

1800–1888. *b. Period of Perfection.—Physiological Period.* Progress of physiology; development of pathological anatomy; gradual limitation of craniotomy; study of physiological labor.	1. Physiological Period, 1800–1847. Instrumental interfering obstetrics of Levret and Smellie yield to the physiological practice of Solayres and Baudelocque.	Perfection of the low-forceps operation; instrumental interference limited more and more to definite indications; the obstetric chair passes away; increased opposition to craniotomy; craniotomy replaced in part by the forceps in England and France, by version in Germany, and the reappearance of the operation for the induction of premature labor, 1831; introduction of ergot by Stearns of New York, 1807; embryological work of Meckel, 1812. Teachings of Baudelocque characterize this period, to allow nature to complete labor if possible, and interfere only if nature fails.
	2. Discovery of anæsthesia and the infectious nature of puerperal fever, 1847–1870.	Discovery of ether by Morton in 1841; application of anæsthesia to obstetric practice by Simpson, 1847, and Channing, 1848; infectious nature of puerperal fever suggested by O. W. Holmes, 1845; demonstrated by Semmelweiss, 1847; combined version introduced by Wright of Cincinnati and Braxton Hicks of London, 1854.
	3. Antiseptic Era, 1870–1880. Prevalence of carbolic acid and prophylactic vaginal and intra-uterine injections. 1880–1888. Prevalence of corrosive sublimate and aseptic prophylactic methods.	Perfection of the high-forceps operation; utmost limitation of craniotomy; introduction of antiseptic method in obstetric practice by Stadtfeldt of Copenhagen, 1870; prevalence of carbolic acid; prevalence of active measures and intra-uterine injections; introduction of Porro's operation, 1876; of Tarnier's axis-traction forceps, 1877; of the bichloride of mercury by Tarnier, 1881; prevalence of prophylactic or aseptic practice and the use of the bichloride; prophylactic vaginal and intra-uterine injections proven dangerous and unnecessary; perfection of the conservative Cæsarean section by Saenger, 1884.

Note to Article on History of Obstetrics.

Misled by the universal acceptance of the erroneous statement that the first step toward the introduction of *aseptic* obstetrics, and the abandoning of the overdone meddlesome, and dangerous *antiseptic* practice, was due to Runge, assistant to Prof Gusserow, and Hofmeier, assistant to Prof. Schroeder, I have made the same assertion repeating it, as other authors have done, without further investigation.

The step was one of such import, and of such influence upon the future of obstetric science, that it is but right that the prevailing error should be corrected and the merited honor properly given to the deserving obstetrician by whose judgment the dangerous tendencies of the violent prophylactie antiseptic practice were checked and the correct aseptic inaugurated.

It was Runge who first denounced the then prevailing prophylactic as well as therapeutic use of the intra-uterine douche: his paper, based upon observations in Prof. Gusserow's obstetric wards in the Charité, appeared in the *Berliner klinische Wochenschrift*, 1880, Nos. 43–46, and in the *Zeitschrift für Geburtshülfe*, vol. v., 1880, p. 195; also *Volkmann*, No. 237.

In consequence of the advanced position taken by Runge, Gusserow was denounced, and for a time the prophylactic douche, as still advocated by the followers of Schroeder, continued its sway.

Not until a later date did Schroeder withdraw from his dangerous course, and then his assistant, Hofmeier, gradually acknowledged the dangers of the prophylactie method and appeared as an advocate of the aseptic practice previously adopted in the wards of Prof. Gusserow. Possibly an article by Hofmeier (*Zeitschrift für Geburtshülfe*, 1880, vol. v. p. 175) questioning the value of the prophylactic, but upholding the therapeutic, douche may have given rise to the coupling of his name with that of Runge as an instigator in the aseptie movement.

In the face of opposition and ridicule, especially on the part of Hofmeier, Runge abandoned the prophylactic douche and outlined the more reasonable aseptic practice which has long since been everywhere accepted, and to him should be given the credit as being the pioneer among German obstetricians.—(*See p. 59.*)

THE PHYSIOLOGY AND HISTOLOGY OF OVULATION, MENSTRUATION, AND FERTILIZATION: THE DEVELOPMENT OF THE EMBRYO.

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I. OVULATION.

INTRODUCTORY.—In this article an attempt will be made to give a short account of the phenomena of ovulation, menstruation, and embryonic development from the standpoints of the morphologist and physiologist. The practical bearings of the facts or the theoretical views which may be put forward are, for the most part, left to be treated of by other contributors to this volume.

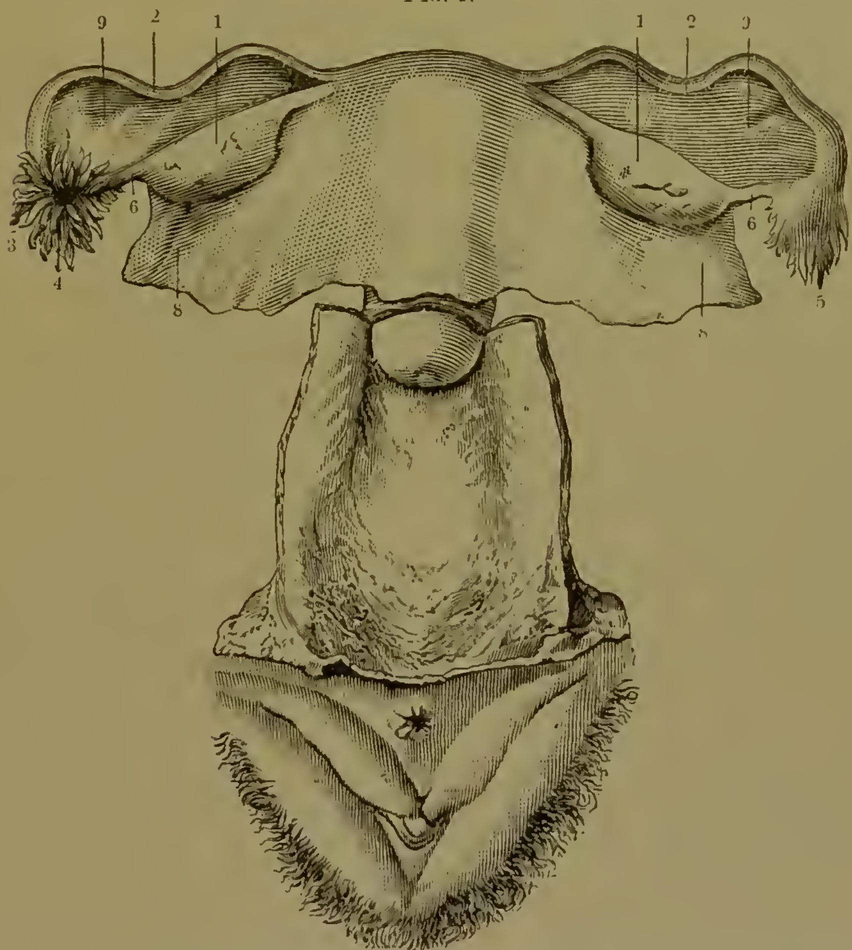
"Life is a cycle beginning in an ovum [or spermatozoon], and coming back to an ovum [or spermatozoon] again." Any but an incidental discussion of the origin and nature of the spermatozoon would be beyond the limits allotted us. We shall therefore commence with the ovum; next, consider the uterine processes (menstruation) which prepare the uterus to nourish the fertilized egg; and conclude with a brief account of the development of the embryo up to the time of the origin in it of new ova.

Structure of the Ovaries.—The adult ovaries are dense fibrous ovoid masses, usually weighing about 5.5 grams (78 grains). They are somewhat flattened in one of their transverse diameters, the average measurements of the three diameters being 38, 19, and 13 millimeters ($1\frac{1}{2}$, $\frac{3}{4}$, $\frac{1}{2}$ inch), respectively. Each ovary is attached by one border to the broad ligament of the uterus; its opposite border and both flattened sides are free. The attached border is named the *hilus*, and along it vessels and nerves enter and leave the organ. One of the processes or *fimbriæ* of a Fallopian tube is adherent to the outer upper end of each ovary (Fig. 1).

The ovary may be described as consisting of a ground substance or *stroma;* of egg-containing cavities, the *Graafian follicles,* scattered through the stroma; of an *epithelium* covering the ovarian surface except at the hilus; and of blood-vessels, lymphatics, and nerves.

The Ovarian Epithelium.—The broad ligament is covered by simple scaly epithelium resembling that on the surface of other parts of the peritoneum, and presents a smooth, glistening surface. In young

FIG. 1.



Female Organs of Generation from behind (from Quain, after Sappey): 1, ovaries; 2, Fallopian tubes; 3, 4, 5, fimbriated extremities of the Fallopian tubes; 6, ovarian fimbria; 8, 9, broad ligaments.

adults the epithelial surface of the ovary is also smooth, but it presents a duller, less shiny surface. This difference of appearance is correlated with the fact that the epithelium covering the ovary differs in structure from that of the general peritoneum: it is made up of a layer of cylindrical or columnar cells, and in the embryo very early assumes this special character, and is set apart for the formation and nourishment of ova (see p. 195). This function it probably retains to some extent until the procreative life of the woman has ceased, as among its cells one can usually find, until the climacteric, some which are larger and rounder than the rest, and closely resemble the embryonic primordial ova.

The Stroma of the ovary consists fundamentally of a close feltwork of white fibrous and yellow elastic connective tissues richly supplied with nucleated corpuscles. The majority of the latter are spindle-

FIG. 2.

Section of Ovary of Cat (Schrön): 1, outer covering and free border of ovary; 1', hilus; 2, 3, ovarian stroma; 4, blood vessels; 5, young Graafian follicles; 6, 7, 8, more mature follicles; 9, a follicle nearly ripe; 10, corpus luteum.

shaped, but in the neighborhood of the blood-vessels there may be found numerous polyhedral or irregularly-shaped cells, which often contain yellow pigment: these are the so-called *interstitial cells*, and increase in number and are more widely distributed through the ovary as age advances. Immediately beneath the epithelial layer the fibrous stroma is especially dense, forming a thin, very tough stratum. This has been called the *tunica albuginea ovarii*, but it insensibly grades off into the deeper layers of the stroma, and does not form a distinct separable coat comparable to the tunica albuginea of the testis.

Along the hilus, blood-vessels, lymphatics, and nerves enter and leave the ovary: they branch through the stroma, forming part of it. The arteries and veins are comparatively large at the hilus and in the centre of the ovary, but divide into minute twigs near the surface. A certain amount of plain muscular tissue lies near the arteries.

The Graafian Follicles, or egg-chambers, are numerous. In the ovaries of a newborn female infant there are about seventy thousand of them, and probably additional ones are developed during life. From their size and arrangement they fall into two groups: the smaller and simpler are closely packed just beneath the *tunica albuginea*, and constitute the *cortical layer* of the ovary. In this layer most of the follicles have a diameter of about one-fourth of a millimeter ($\frac{1}{100}$ inch); they have no differentiated enclosing capsule, and consist merely of a

FIG. 3.

Section through Part of Ovary of Adult Bitch (from Waldeyer): *a*, germinal epithelium; *b*, ingrowths (egg-tubes) from the germinal epithelium, seen in cross-section; *c*, *c*, young Graafian follicles in the cortical layer; *d*, a more mature follicle, containing two ova (this is rare); *e* and *f*, ova surrounded by cells of discus proligerus; *g*, *h*, outer and inner capsules of the follicle; *i*, membrana granulosa; *l*, blood-vessels; *m*, *m*, parovarium; *g*, germinal epithelium commencing to grow in and form an egg-tube; *z*, transition from peritoneal to germinal epithelium.

spherical case of cells which closely invest, and presumably nourish, the young ovum.

In the least developed follicles the investing cells are flattened (*a*, Fig. 4); the ovum has no cell-wall, and consists merely of a minute mass of mixed protoplasmic and nutritive material forming the cell-body or yolk or *vitellus*, *b*, containing a cell-nucleus or *germinal vesicle*, *c*, within which is a well-marked nucleolus or *germinal spot*, *d*.

Origin of the Graafian Follicles.—Many Graafian follicles are formed during early embryonic life by ingrowths from the germinal epithelium covering the ovary, but the process continues until the age of child-bearing has passed. Rows or cords of cells burrow (*g*, Fig. 3) from

FIG. 4.

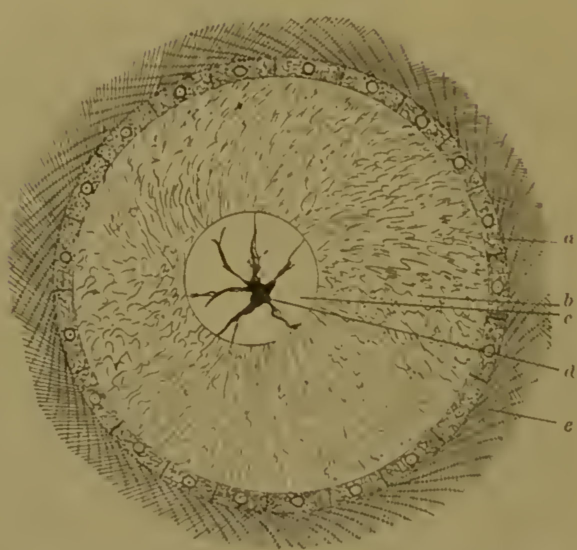


Diagram representing Structure of Young Graafian Follicle: *a*, investing cells; *b*, vitellus; *c*, germinal vesicle; *d*, germinal spot; *e*, ovarian stroma.

the epithelium into the stroma of the ovary. In these egg-cords certain cells, *the primitive ova* (Fig. 5), enlarge and become more granular and rounder than the rest. Ingrowths of the stroma next cut off the connection between the egg-cord and the epithelium, and also divide the cord up into a number of pieces, each containing a primitive ovum (rarely two) surrounded by a number of investing cells. Thus from each cord a number of young Graafian follicles are developed. Some of the stages of the process are represented in Fig. 5.

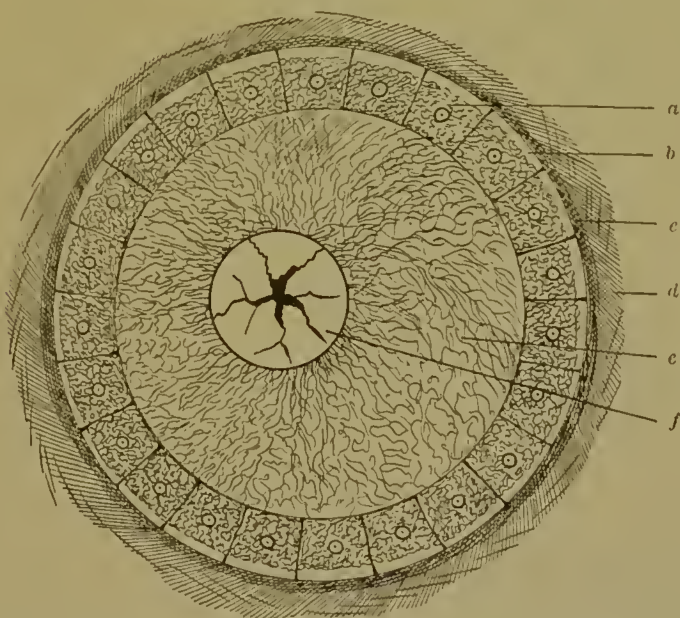
FIG. 5.

Section through Part of a Mammalian Ovary (after Wiedersheim): *KE*, germinal epithelium; *PS*, an egg-cord; *U*, primitive ova; *G*, investing cells; *K*, germinal vesicle; *S*, follicular cavity arising in one of the older follicles; *Lf*, follicular cavity, more enlarged; *Ei*, nearly mature ovum, which has developed around it the zona pellucida, *Mp*; *Mg*, membrana granulosa; *D*, discus proligerus; *So*, ovarian stroma; *Tf*, capsule of follicle.

When a follicle commences to ripen it recedes from the surface of the ovary and increases in size, and also becomes more complex in structure. Just below the cortical layer one finds in the normal adult ovary follicles, the investing cells of which are cuboidal; at their outer ends is a thin transparent layer, the *membrana propria*, which separates them from the stroma (Fig. 6). The stroma itself is somewhat condensed, and its fibres more closely interwoven immediately around the follicle, and thus forms a sort of *capsule* for it. As maturation of the follicle proceeds, the investing cells become columnar, and then they multiply and become two layers thick, so that the ovum becomes invested by two layers of cells, by a *membrana propria*, and by a fibrous capsule. The inner layer of the investing cells is probably formed by division of the cells of the primary single stratum.

In riper and more deeply-placed follicles the cells of both investing layers are found to have multiplied, and a considerable quantity of

FIG. 6.



A Graafian Follicle a little more mature than shown in Fig. 4 (diagrammatic): *a*, investing cells; *b*, membrana propria; *c*, commencing capsule of follicle; *d*, ovarian stroma; *e*, vitellus; *f*, germinal vesicle.

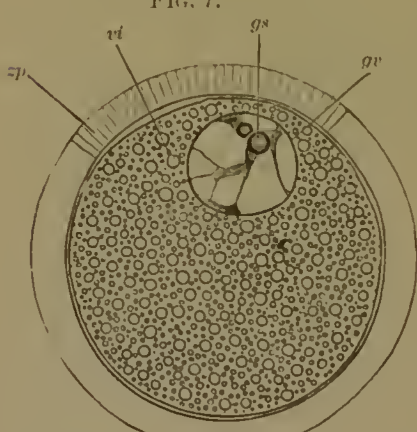
albuminous liquid (*liquor folliculi*) to have collected between them (Fig. 5, *Lf*), except at one region: there the cells cohere, and the ovum is always situated at this place. It thus comes to be excentric in position within the Graafian follicle, the side which it lies next being usually that nearest the surface of the ovary. The cells (*Mg*, Fig. 5) which line the follicle constitute the *membrana granulosa;* those which immediately invest the ovum form the *discus proligerus* (D, Fig. 5).

The follicular liquid contains a form of proteid named *paralbumen*, which differs from ordinary proteids in that it is not coagulated and rendered insoluble in water when precipitated by alcohol. Paralbumen has been found in ovarian cysts.

The maturing follicles increase rapidly in size, partly from the multiplication of the cells within them, but mainly because of the accumulation of follicular liquid. The liquid is probably not a mere transudation, but a true secretion of the cells of the *membrana granulosa*. Meanwhile, the more condensed layer of stroma, which was recognizable as a sort of capsule around less advanced follicles, becomes very distinct and separates into two layers—an inner, very rich in capillary blood-vessels, and an outer, dense and tough and containing arterioles and small veins. The blood-vessels in neither layer spread all the way round the follicle. They become less numerous near its more superficial side, and there converge toward a small area which is entirely non-vascular and is known as the *stigma*. At the stigma the follicle finally bursts when the egg is discharged.

As the follicular liquid increases, the tension exerted by it distends the follicle, causing it to press on the surrounding tissues. These give way most in the line of least resistance—that is, toward the surface of the ovary, which the stigmatic end of the ripening follicle soon reaches. Here the swelling follicle has to meet the resistance of the tough *tunica albuginea*. This it overcomes, and pushes it out so as to form a swelling on the surface of the ovary. This swelling is covered by the ovarian epithelium, the tunica albuginea, and the walls of the follicle; but all these layers are here very thin, and contain few or no blood-vessels: when ripe and ready to burst, the follicle has a diameter of from 1 to $1\frac{1}{2}$ millimeters ($\frac{1}{25}$—$\frac{1}{17}$ inch). The *discus proligerus*, with the ovum imbedded in it, usually lies near the outermost end of the projecting follicle. Observations on the lower animals show that follicles in this condition are very easily burst, and that they then extrude the follicular liquid, which carries with it the ovum and some of the cells of the discus proligerus and membrana granulosa.

Fig. 7.



Nearly Ripe Ovum of Cat (semi-diagrammatic): *zp*, zona pellucida or zona radiata; *vi*, vitellus; *gv*, germinal vesicle; *gs*, germinal spot. (After Schäfer.)

The Egg-membranes, or Coats of the Ovum.—While the Graafian follicle has been distending and ripening, the egg, buried in the discus proligerus, has developed three coats or cell-membranes. By far the most distinct of these in the mammalian ovum, and the longest known, is a translucent radially-striated membrane, the *zona radiata* or *zona pellucida*, *zp* (Fig. 7).

Outside the zona radiata is an irregular granular membrane, which is the first-formed cell-wall of the ovum, and is known as the *vitelline membrane* (*c*, Fig. 8). Inside the zona is a delicate membrane, the third proper coat of the ovum, which only develops as the ovum approaches maturity (*e*, Fig. 8). The diagrammatic representation in Fig. 8 may help to the understanding of the structure of the ovum and of its relationship to the follicle at this stage, but it must be borne in mind that the figure is a mere diagram. It represents a section through part of a

FIG. 8.

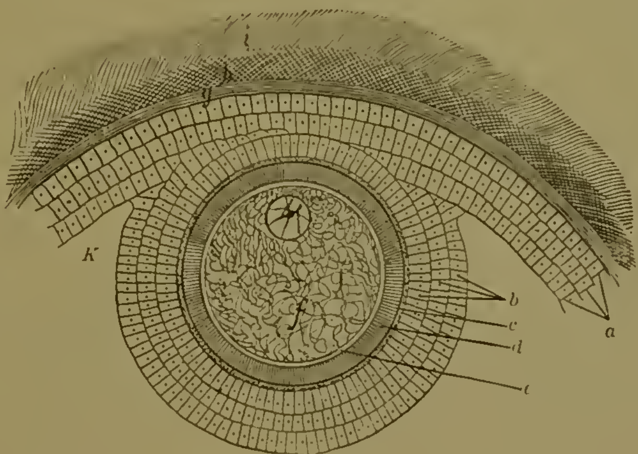


Diagram of Section through nearly Mature Ovum and Part of Graafian Follicle: *a*, cells of membrana granulosa; *b*, cells of discus proligerus; *c*, vitelline membrane; *d*, zona pellucida; *e*, internal cell-membrane of ovum; *f*, vitellus; *g*, inner vascular layer of capsule of follicle; *h*, outer fibrous and less vascular layer; *i*, general ovarian stroma; *K*, follicular cavity filled with follicular liquid.

nearly mature Graafian follicle, passing through the ovum and discus proligerus.

The Properties of the Unfertilized Ovum.—In early stages of its development the ovum, as already stated, consists of a mixed mass of protoplasm and food-material, the *vitellus*, imbedded in which is a germinal vesicle containing a germinal spot. The protoplasm has the faculty, possessed only by living matter, of taking up other substances (foods) into itself and transforming them into matter like itself and possessing the same properties. Egg-protoplasm has in addition the tendency and the faculty to constrict and divide along certain lines, and thus to separate into two or more pieces, which become distinct living units or *cells*. This tendency to division or *segmentation* of the ovum is greatly increased by *fertilization* (p. 97), and then leads to the formation of the embryo. The other chief constituent of the vitellus, the food-material, is constantly supplied by the cells surrounding the young ovum: it is usually granular, and gives the whole vitellus its cloudy, semi-opaque appearance, the pure protoplasm being transparent and showing no structure when examined with the microscope. There may also be in the egg, mixed with the protoplasm, waste matters produced by the breaking down of protoplasmic material, as a result of its activity. The food and other matters mixed with the protoplasm are named collectively *deutoplasm* or *paraplasm*.

Holoblastic and Mesoblastic Ova.—In all eggs the absolute quantity of genuine protoplasm is small: in the human ovum and in the eggs of the higher mammals there is also but little deutoplasm. The whole ovum in such cases is microscopic in bulk, and the protoplasm is tolerably evenly diffused throughout it. When ova of this type segment after fertilization, they divide completely into a number of similar cells, and these cells live and multiply for a time by using the deutoplastic food-material which each contains. But the quantity of deutoplasm being small, the segmenting egg (= young embryo) has soon to seek food from other sources; for example, in the higher mammals from the secretions of the Fallopian tubes and the mucous membrane of the womb, and later from the placenta.

The actively-living, segmenting, and assimilating protoplasm of an egg has been distinguished, under the name of *germ-yelk*, from the secondary food-material (deutoplasm), which is known as the *food-yelk*.

In the eggs of many animals the quantity of food-yelk is vastly in excess of that of the germ-yelk. In such cases most of the germ-yelk is collected at one point near the surface of the vitellus, the rest of it being distributed as a wide-meshed reticulum which holds together the granules of the food-yelk. In these eggs the concentrated germ-yelk alone segments, and the new cells to which it gives origin by division gradually absorb and assimilate the great mass of food-yelk. The embryo is thus nourished by material stored in the egg, as in the typical instance of a hen's egg, in which the developing chick needs no extraneous supply of any kind of food, except oxygen, until after it is well developed and has been hatched. Lime salts from the shell, albumen and salines from the white, albumens and fats from the food-yelk, are all taken up and assimilated by the developing chick. In such cases no placenta is formed, and the uterus, after taking its share in the formation of the white and shell of the egg, has nothing further to do with the nutrition of the embryo.

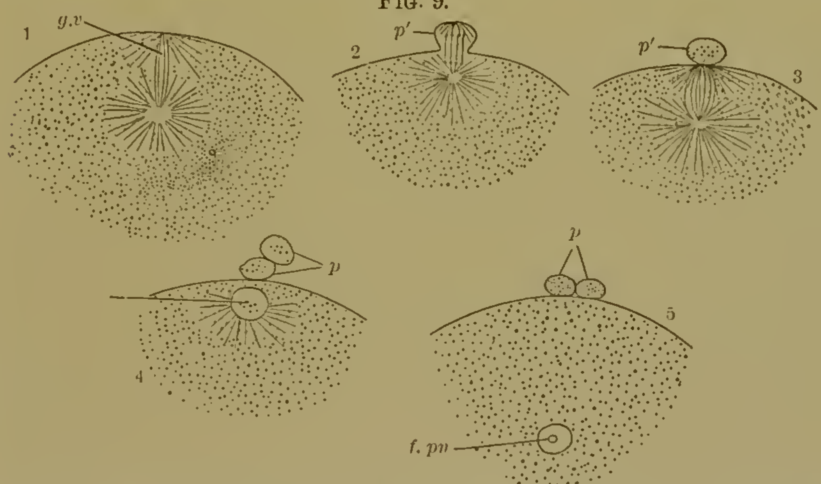
An egg which completely segments is *holoblastic*; one which partially segments, leaving some unsegmented food-yelk to be later absorbed by the embryo cells, is *mesoblastic*. The human ovum is holoblastic.

Comparative embryology shows that there is no sharp dividing-line between mesoblastic and holoblastic ova. In the egg of the frog, for example, a considerable proportion of food-yelk is present, but not enough to prevent complete segmentation. However, there is a much larger proportion of it in one-half of the egg than in the other; and this half segments more slowly and forms larger cells than does the other half, richer in germ-yelk. Many other intermediate stages between the two chief types of ova might be given.

The Maturation of the Ovum.—The details of the ripening of the ovum and its preparation for fertilization have not yet been directly observed in human ova; but from what has been seen to occur in eggs of a large number of the lower animals, we may safely conclude that the process is as follows:

The germinal vesicle or nucleus elongates in a radial direction, and as a whole moves toward the surface of the egg. It loses its definite boundary, and the germinal spot also becomes indistinct. Indeed, according to older embryologists, the germinal vesicle and spot entirely disappear: it is only advances in histological technique made during the last twenty years which enable the nucleus to be detected at this stage. As the nucleus elongates (Fig. 9) the egg-protoplasm near the nuclear

Fig. 9.

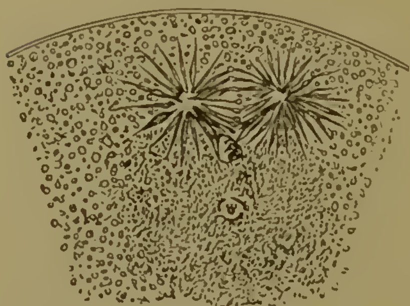


Stages in the Formation of the Polar Globules in an Ovum (after Hertwig): *g. v*, germinal vesicle or egg-nucleus undergoing karyokinesis; *p'*, the first polar globule in process of extrusion, and (3) extruded; *p*, both polar globules extruded; *f.pn*, female pronucleus.

poles shows a radial arrangement, the radii converging toward each pole, while striations unite the two poles. This phenomenon is now well known as occurring in the phenomenon of nuclear division as preliminary to ordinary cell-division: the germinal vesicle and the germ-yelk behave exactly like the nucleus and protoplasm of any normally dividing cell. The phenomenon is named *karyokinesis,* and cannot here be described in detail. The lines uniting the poles of the nucleus disappear, and the nuclear matter collects at each pole, forming two new nuclei, around each of which the germ-yelk still shows a radial arrangement. The result is a couple of star-like figures (Fig. 10), and is known as the "amphi-aster" stage in nuclear development.

In the ovum one of the new nuclei moves to the surface, and is extruded along with a small amount of the egg-protoplasm, the extruded nucleus and its accompanying protoplasm being known as the first *polar globule*. The process is then repeated, and a second polar globule extruded (*p*, Fig. 9). There can be no doubt that the phenomenon is a true cell-division, exhibited by the unfertilized ovum, and in some way preparatory to fertilization. The egg divides into a large cell and two small cells; the latter, or polar globules, contain some of the nucleus and some of the protoplasm of the original egg-cell, and are not known to play any further part in the development of the embryo. The larger cell resulting from the division becomes the mature ovum. That portion of the original nucleus remaining in it recedes from the surface; it soon assumes all the optical characters of an ordinary germinal vesicle, with its nucleolus, and the radial arrangement of the yelk surrounding it is lost: in this condition it is known as the *female pronucleus*. We shall show later, in more detail, that the fundamental fact in fertilization of the ovum appears to be the fusion of a *male pronucleus*, derived from the body or head of a spermatozoon, with this female pronucleus, found in the egg after extrusion of the polar globule.

Fig. 10.



An Ovum in the Amphi-aster Stage (Balfour, after Fol).

That the segmentation of the egg-cell and extrusion of the polar body, as a preliminary to the capacity of the egg to be fertilized, have a meaning, no one can doubt. They may be mere remnants of some ancestral process which occurred in primitive living matter; and the fact that polar bodies are found both in plants and animals indicates that they originated very early in the evolution of living things. But, granting this, we may fairly assume that had the process no practical physiological importance, it would, in the course of evolution, have been eliminated from the developmental history of the higher plants and animals; and this we know not to be the case. There is, in fact, as yet no satisfactory theory as to the meaning of, or the reason for, the formation and separation of the polar bodies.

The main theories maintained are: 1. The polar bodies are merely matter useless to the ovum and excreted by it (Bütschli, Strasburger, Hertwig). 2. (Minot, Balfour.) The removal of the parts of the nucleus and protoplasm carried off in the polar bodies leaves the ovum an incomplete cell, requiring for its completion and further development and multiplication new nuclear and other protoplasmic matter from outside, thus making possible the fusion and co-operation of the male element, and facilitating cross-fertilization, with its beneficial results.

The lower animals and plants frequently multiply without any sexual process. The organism, usually unicellular, divides up in some one of several known methods into two or more cells which become independent individuals. In the higher plants and animals the individual cells which cohere to compose the whole complex mass, and which, nevertheless, have their own more or less independent life, usually multiply in this *asexual* manner. The definition of *sexual reproduction* is the coalescence of materials derived from two cells as a necessary preliminary to the formation of a new individual of the species. In nearly all the more complex, or multicellular animals, growth is effected by asexual cell-multiplication; but reproduction is effected by a sexual process; by the fusion of material derived from two cells. In certain cases, however, even in complex animals and plants, what is known as *parthenogenesis* occurs; that is to say, a reproductive cell resembling an ovum multiplies and develops a new individual without fertilization. It is noteworthy that parthenogenetic development is frequent in insects and wheel-animalcules, and that it is in exactly these groups that the separation of a polar body from the ovum is still in doubt. This fact may perhaps be taken provisionally as an evidence that the extrusion of a polar body is antagonistic to parthenogenesis. Balfour therefore suggests that *the function of forming polar cells has been acquired by the ovum for the express purpose of preventing parthenogenesis.* Parthenogenesis of the ovum would result in the closest kind of in-breeding, and the ill results of this and of self-fertilization when continued have been long recognized, and have been satisfactorily explained by Darwin.[1]

Ovulation, or the Discharge of the Ripe Ovum.—While the egg is ripening the Graafian follicle travels toward the surface of the ovary, and becomes larger and more tensely filled by liquid. Finally, it projects from the surface of the ovary. Its wall is thinnest at its most prominent part, and at this place contains no blood-vessels. This projecting, thinnest, and non-vascular part of the coat of the follicle is known as the *macula* or *stigma*. It finally bursts, and the ovum is discharged along with the follicular liquid, and still imbedded in the cells of the discus proligerus.

The ripening and discharge of ova is a periodic process. In many of the lower animals it only occurs at intervals of a year or a month or a week, and the female only at these epochs exhibits sexual appetite, and will only then permit the access of the male. Except in the human female and in a few races of domesticated animals, ovulation occurs in mammals at certain seasons of the year only, and these seasons are correlated with the duration of pregnancy in the species, so that the young shall be born at a time when the food-supply of the parents in their native haunts is most likely to be abundant. In the human race there

[1] *Cross- and Self-fertilization in the Vegetable Kingdom.*

is reason to believe that ova are especially apt to ripen and to be discharged at or about the menstrual epochs, though there is evidence that eggs may occasionally mature and be set free in intermenstrual periods. In other words, the activity of the ovary which results in ovulation, and the activity of the uterus which results in menstruation, in the vast majority of cases have the same period and nearly coincide in time of occurrence; but either may take place without the other in exceptional instances.

Whether copulation has any influence in promoting the discharge of the ovum is a question which cannot be yet satisfactorily answered. It is certain that ovulation may and does occur and recur regularly without sexual congress in mammals: if sexual congress has any influence, it can only be a mere hastening of a normal periodic process; that ovulation can be so hurried is not proven.

The main arguments in favor of the view that sexual congress promotes the ripening or discharge of ova are these: *a.* In some plants (*orchids*) the ovaries only ripen weeks or months after the pollen-grains have been deposited on the stigma and sent forth their pollen-tubes toward the ovary. *b.* Clarke[1] observed that one of the tortoises (*Chrysemys picta*) laid fertile eggs only when eleven years old, but for several previous years copulated twice annually. From this Clarke concluded that sexual congress promotes the ripening and discharge of ova. Something similar has been observed in a few other animals (Coste,[2] Schneider[3]). But these must be regarded as exceptional cases yet to be explained: in the vast majority of animals and plants the ova ripen quite independently of sexual congress. An acute sexual orgasm in the woman may lead to the slightly premature bursting of ripe Graafian follicles and to conception; but there is no good reason for believing that, so far as the human female is concerned, sexual congress has any important influence on the maturation or discharge of ova ready for fertilization.[4]

Reception of the Discharged Ovum by the Fallopian Tube.—In most animals the oviduct is a mere duct continuous directly with the ovary, and carrying off the eggs and all other matters secreted by that gland. But in the higher vertebrates and in many invertebrates this is not the case: in them the oviduct is not directly continuous with the cavity of an egg-secreting gland, but is a separate and distinct tube, known as the *Fallopian tube*. In the mammals (including the human race) the Fallopian tubes, which are two in number (right and left), meet and form a single cavity, the *uterus*. In the uterus the layer of involuntary or unstriped muscular tissue present in the walls of the Fallopian tubes

[1] *Contributions to Natural History*, edited by L. Agassiz, ii. p. 490, Boston, 1867.

[2] *Histoire du Développement*, ii. p. 84.

[3] *Unters. über Plathelminthen*, 1873, p. 40.

[4] See Hensen in *Hermann's Handbuch der Physiologie*, vol. vi. pt. ii. p. 58.

is greatly increased in quantity, and becomes vastly more complex in its anatomical arrangement. The mucous membrane lining the Fallopian tubes is also much altered when those tubes coalesce to form the womb: it becomes thicker, glandular, and very vascular, and will be described in more detail subsequently (p. 83). From the uterus a single tube in the higher mammals (with exceptions in some species of the hare family) leads to the exterior. This tube, the *vagina*, receives the male element necessary to fertilization of the egg, and transmits it to the uterus, and through this to the Fallopian tubes, where it meets the ovum. Fertilization may occur even before the egg enters the Fallopian tube and while it still lies on the surface of the ovary, as is proved by cases of extra-uterine pregnancy. It normally occurs at the upper end of a Fallopian tube.

In the great majority of cases the ripe egg discharged by the ovary is taken into a Fallopian tube, and by the latter conveyed to the womb. If not fertilized on its way to the womb, it develops no farther, and breaks down and is discharged through the vagina. If fertilized, it passes through the first stages of development in the Fallopian tubes, and, slowly reaching the uterus, applies itself to some part of its lining mucous membrane and develops an organ, the placenta, in which the fœtal and maternal blood-vessels are so closely intertwined that by dialysis the blood of the maternal uterus carries off the wastes of the fœtus, which are returned to the external universe by the skin, lungs, and kidneys of the mother. On the other hand, the fœtus gets nourishment from the maternal blood. The uterus of the higher mammalia is an organ designed to nourish the developing fertilized ovum, which, unlike the bird or reptile egg, has very little food in it for its sustenance in the earlier stages of its development. The Fallopian tubes and the vagina are secondary organs, the former to convey the spermatozoa to the ovum and carry the fertilized egg to the uterus; the latter to receive and pass on the seminal fluid, and to afford a passage for the fœtus to the outer world.

Reception of the Ovum by the Fallopian Tube.—In some mammals (bats, *e. g.*) the ovary lies in a closed capsule whose outlet is through a Fallopian tube, but in most, including our own species, this is not the case. The ovary lies quite free in the abdominal cavity, but with the widened fimbriated end of a Fallopian tube close to it. In the human species one of the fimbriæ of the tube (Fig. 1, *6*, p. 69) is attached by a connective-tissue thread to the ovary, and all the fimbriæ are on their inner side covered with ciliated epithelium, which lashes so as to set up a current toward the tube and, through it, to the uterus. The steady flow of peritoneal liquid set up by these cilia in the great majority of cases involves the discharged ovum in its stream, and carries it to the Fallopian tube along the line of the permanently attached fimbria.

The importance of ciliary movements in guiding the ovum to the oviduct is well seen in frogs. In female frogs the lining cells of the peritoneum become ciliated along certain tracts at the time when the eggs are nearly ripe. The ripe eggs are discharged from the ovary into the abdominal cavity, but are gradually carried by the ciliary current to the mouth of the oviduct. After the eggs have been discharged the endothelium of the peritoneum loses its cilia until the next breeding season.

Embryological study, which shows that the oviduct in mammals is but the Müllerian duct of the embryo (p. 191), makes it clear from a morphological standpoint why the oviduct or Fallopian tube is not directly continuous with the ovary. Its discontinuity, however, gives rise occasionally to extra-uterine pregnancies, and in so far the mechanism is physiologically defective. That there is some advantage to our race in the discontinuity of the ovarian gland and its duct, which more than balances the disadvantages, is not likely to be doubted, but what the advantage is no one has hitherto been able to discover. It may be suggested that this discontinuity is but a mere inheritance from ancestral forms (*e. g.* the Annelida), which evolution in its steady working for the benefit of the species has not yet overcome; but to such an opinion stands opposed the fact that even low down in the animal kingdom (Rotifera) we know of genera in which the oviduct is not directly continuous with the ovary, and of other genera or classes in which the oviduct is directly continuous with a hollow ovary, and has the same relationship to it as a salivary duct to a salivary gland (clam, lobster, insects).

II. Menstruation.

Menstruation.—In the great majority of healthy women great changes in the uterine mucous membrane recur periodically from puberty until the capacity for childbearing has been lost with advancing years. These changes take place at intervals of about four weeks in most cases, and result in a breaking down and discharge of much of the uterine mucous membrane, together with some blood. This discharge is known as the *menses*, or *menstrual flow*, or the *catamenia*. It is associated with considerable changes in the general nutritive processes of the woman: her urea excretion through the kidneys is diminished; her temperature is raised about 0.5° C. Feelings of discomfort or weariness (*molimina menstrualia*) are very frequently present at or just before occurrence of the monthly flow, but may be entirely absent.

The Histological Changes of the Uterus during Menstruation.—The mucous membrane of the *cervix uteri* differs in structure from that lining the body and fundus of the organ, and takes no part in the menstrual process. The following statements do not apply to it:

The uterus over most of its outer surface has a *serous coat* derived from the peritoneum: beneath this comes a *muscular coat* of unstriped muscle-tissue, containing also connective tissue, blood-vessels, and nerves; internal to the muscular coat, and closely applied to it, comes the mucous membrane. The outer layer of this membrane is remarkable for the great thickness of its muscular stratum, the *muscularis mucosæ*. This layer of non-striated muscular tissue is found on the deeper side of most if not all mucous membranes, but in most organs is very thin. In the uterus it is very thick, and constitutes the greater part of the thickness of the walls of the virgin organ.

The middle stratum or *corium* of the uterine mucous membrane of the virgin is about one millimeter ($\frac{1}{25}$ inch) thick, and presents a smooth surface except during menstruation. Its basis is a loose vascular connective tissue containing few fibres, but much structureless interfibrillar substance, and having scattered through it very numerous round, fusiform, or irregularly-shaped granular nucleated cells. The inner surface of this corium is lined by a single layer of columnar ciliated cells, and is dotted all over by mouths of tubular glands. These glands traverse the corium as narrow, unbranched cylindrical tubes until they reach the

Fig. 11.

Section of Mucous Membrane of the Uterus near the Fundus (from Ewart after Williams): *a*, epithelium lining the uterus; *b*, *b*, uterine glands; *c*, interglandular connective tissue; *d*, *muscularis mucosæ*, with the deeper ends, *b′*, of the uterine glands, imbedded in it (from Quain's *Anatomy*) specimen prepared from uterus of a young woman who was accidentally killed three or four days before the expected menstrual flow.

muscularis mucosæ, in which their deep ends are imbedded and within which they sometimes branch. They are lined by ciliated epithelium continuous with and resembling that on the inner surface of the womb. Their secretion is colorless, sticky, and alkaline. The movement of the cilia of the lining epithelium of the uterus is such that liquids within it are driven toward the *os* and from the *fundus*.

Shortly before the occurrence of the menstrual flow the corium of the uterine mucous membrane grows very fast. It becomes five or six times its usual thickness; its lymph-channels widen, its glands become longer and wider, and it forms a thick cushion filling up the cavity of the body of the womb. Next, the blood-vessels of the membrane become gorged, and either some of them burst and extravasation occurs, or many red corpuscles bore their way (diapedesis) through the walls of the capillaries. Whether the process is extravasation or diapedesis is not yet certainly known, but the former is more probable. Once outside the vessels, some of the blood reaches the uterine cavity, and the rest lies among the tissues of the corium for a time. The amount of blood discharged at a menstrual period varies much even among healthy women. The normal amount is probably somewhere between 100 and 200 grams (5–10 ounces). The discharged blood is mingled with detritus and secretion from the mucous membrane, and before reaching the external opening of the vagina the mixture has usually undergone some decomposition, giving it an unpleasant odor. Hence, probably, the old notion that the menstrual blood was a purification of the woman, removing from her body noxious substances. Perfectly fresh menstrual blood taken from the uterus exhibits no abnormality and clots like ordinary blood. In its passage through the cervix and vagina it usually is mixed with so large a proportion of the secretions of those parts that it will not afterward clot.

After the blood has been passed out, the tissues of the thickened mucous membrane break down. The epithelium cells, the cells lining the necks of the glands, and the connective-tissue corpuscles of the corium, all undergo a sort of fatty degeneration. Usually they fall to pieces completely, and are discharged as a structureless detritus in the secretions of the last days of the menstrual flux, which, instead of being bloody, becomes brown or often nearly colorless. Sometimes, however, coherent patches of the lining cells of the uterus are discharged, or even its whole epithelium in one piece.

During this later stage of menstruation the uterine mucous membrane rapidly decreases in thickness and regains its normal intermenstrual character, the new epithelium to line the uterine cavity starting from the cells of the deeper parts of the glands which were not destroyed during menstruation. Each gland forms a focus from which new epithelium spreads, as each bit of skin transplanted by the surgeon to the surface of a large cutaneous ulcer forms a focus from which new epidermis develops.

After nine or ten days from the onset of menstruation the new uterine mucous membrane is completely formed, and it remains in a passive state for about eighteen days, until thé commencement of the next menstrual epoch. After the first menstruation the corium of the mucous membrane never returns to its original thickness of about one millimeter ($\frac{1}{25}$ inch). It is henceforth at least twice as thick.

The Duration of the Menstrual Flow varies very much in healthy women. It may last only three days or extend to seven. The Mosaic ritual prescribed seven days as the time of the "impurity" of women.

The Periodicity of the Menstrual Flow is also very variable, but twenty-eight days is usually regarded as the normal period, though many healthy women menstruate regularly at intervals longer or shorter than this. More women menstruate during the first quarter of the moon than during any other quarter.

The Average Age at which the First Menstruation Occurs has been the object of many statistical researches. It is influenced by race, climate, mode of life, and other conditions, so that great differences prevail between the results of different authors. In temperate climates and the Anglo-Saxon and Teutonic races the first menstruation occurs oftener in the fifteenth than in any other year, but the preponderance of this year over the fourteenth and sixteenth is very slight.

Krieger[1] collected and collated 6550 cases in Germany. 1.59 per cent. menstruated first between the ninth and twelfth years; 9.236 per cent. in the thirteenth; 18.213 per cent. in the fourteenth; 18.931 per cent. in the fifteenth; 15.664 per cent. in the sixteenth; 11.572 per cent. in the seventeenth; 8.885 per cent. in the eighteenth; 6.488 per cent. in the nineteenth; 4.29 per cent. in the twentieth; 1.694 per cent. in the twenty-first; between the twenty-first and thirty-first years, 1.43 per cent.

It seems also to be well established that, other things being equal, city-bred girls menstruate from six to twelve months sooner than those reared in the country. This is probably due to the more stimulating social life of the city and the more frequent association with males for purposes of recreation. Something similar occurs in cattle; two-year-old heifers kept in a pasture rarely go into heat, but it is well known to cattlemen that if let run loose on the ranges they frequently take the bull and become pregnant when they are two-year-olds: as the cowboy puts it, the bulls "tease" them, and the result is an earlier sexual maturity.

[1] E. Krieger: *Die Menstruation, eine Gynäkologische Studie,* Berlin, 1869 (quoted by Hensen, *Hermann's Handbuch,* vol. vi. part ii. p. 65).

As to climate, most observers agree that the onset of menstruation is earlier in hot than in temperate regions, and in temperate than in cold.

The influence of race under similar climatic influences and conditions of life may be illustrated by the observations of Joachim[1] in Hungary: he found the average age of Slav girls at the first menstruation was sixteen to seventeen years; of Magyars, fifteen to sixteen; of Jewesses, thirteen to fourteen. Tilt's observations may also be quoted in this connection: he found that Hindoo women in Calcutta usually menstruated before the twelfth year (average, eleven years and eleven months), while among the negroes in Jamaica (where the temperature is about the same) the average age at the first menstruation is nearly fifteen years (fourteen years ten months).

When we take into account the variety of races, the great differences in climate, and vast intervals between the extremes of city and rural life which exist in the United States, it is clear that no special age can be stated as the most normal for the onset of the menses in American women. It usually occurs some time between the beginning of the fourteenth and the end of the sixteenth year.

General Bodily Changes associated with the First Menstruation.—The occurrence of menstruation indicates that *puberty* has been reached—that the girl has become a woman and capable of becoming a mother: it is associated with or somewhat preceded by other phenomena both material and mental. The womb and vagina enlarge; the external labia increase in size and more completely cover the underlying parts; scattered hairs develop on them and also on the *mons Veneris*, which becomes more prominent. The breasts swell and the nipples project. The pelvis enlarges, and the buttocks and thighs develop more subcutaneous fat and become larger and more rounded; and there is in many cases an increased accumulation of fat beneath the skin of most of the body, making all its contours more rounded and graceful. The mental changes are manifested by the occurrence of sexual desires and many secondary phenomena which proceed from them.

The Cessation of Menstruation is as indeterminate as its onset. It usually takes place between the forty-fifth and the fiftieth year. This cessation (climacteric) is sometimes succeeded, especially in unmarried women, by a loss of feminine anatomical traits and the assumption of some of the bodily characteristics of the man. The form in such cases becomes more angular, the voice harsher, and an imperfect moustache or beard may develop.

During Pregnancy and Lactation the Menstrual Flow usually Ceases, but as regards lactation often for some nine or ten months only. Accord-

[1] *Schmidt's Jahrb.*, lxxxiii. p. 56 (quoted by Hensen in *Hermann's Handbuch*).

ing to Hogg,[1] about 1 per cent. of pregnant women continue to menstruate until they are four or five months with child. But pathological bleedings are often distinguishable with difficulty from menstrual flows, and probably in many of these cases were not distinguished from them. Hogg's tables also tend to show that 0.14 per cent. of pregnant women menstruate until the time of parturition, but here again we probably should make allowance for blood-flows which were not true menstruations. Cases are, however, not infrequent in which a single imperfect menstrual flux takes place at the period next following conception.

The Physiological Significance of Menstruation.[2]—Why menstruation should occur in women during the childbearing age, and what the use of it is, are questions which must have forced themselves on mankind ever since our race began to think about the why or the wherefore of anything.

The most prominent fact in connection with the catamenia being the bloody discharge, this at first was the thing chiefly regarded, and the physiologists and physicians of olden times strove to account for the phenomenon by giving a reason for the discharge of this blood. One theory was that the healthy body might come to contain too much blood, and that the discharge of some of it was essential to health. Aristotle and, from his time down to and including Haller, many naturalists held this opinion, and explained menstruation as a process necessary to get rid of the excess of blood which had collected in the body of the woman, either locally or generally. This "plethora" doctrine in a wider form extended even into comparatively recent times, and led to the annual spring bloodletting to which our grandfathers and grandmothers subjected themselves.

Another opinion, even older than that of the Greeks, was that of the Jews, indicated in the Mosaic ritual, that impure matters collected in the woman's blood and were discharged in the menstrual flux, which was therefore a purification. The arch-charlatan Paracelsus and the honored physiologist and embryologist De Graaf held this doctrine. Our present knowledge shows that the blood-flow is a secondary, and not the primary fact in menstruation, but there may be some truth in a modification of the "purification" theory. One important function of the mucous secretion of the alimentary canal appears to be that the mucus entangles and carries on with it to the rectum indigestible and other possibly harmful solid particles, as microbes. The uterus not merely cleanses itself by secretion and expulsion of mucus, which might sweep and cleanse its lining membrane, but discharges during menstruation all the superficial parts of that membrane. We know

[1] *Med. Times and Gazette*, 1871.

[2] For a fuller discussion of this question, see Hensen in *Hermann's Handbuch*. Much of the following three or four pages is translated from him, with but slight change.

that lying-in women are especially apt to be infected by pathogenic bacterial organisms; and in the earlier stages of its evolution, when the egg is still segmenting and the decidua reflexa forming, it may well be that the young embryo might be easily infected by extraneous organisms. This view gives us one logical meaning for menstruation. It gives us a reason for that entire casting off of the surface-layers of the mucous lining of the womb which occurs each month. Menstruation breaks down and discharges all the old mucous membrane, and gets rid of bacteria which may have entered through the *os* and found in the womb a suitable nidus for development. Hence in a modified form the purification doctrine is still tenable as giving a physiological reason for menstruation.

Another theory, still held by some, is that menstruation represents a "missed" conception—that the uterus, having been all prepared to nourish an embryo, got rid of this accumulated excess material in the menses when conception did not occur at the time of ovulation. An exactly contrary view has been put forward by Naegele[1] (1812)—namely, that menstruation renews a capacity for conception which had been gradually lost by the uterus in the intermenstrual period—that menstruation was a rhythmical renewal of the embryo-nourishing power of the uterus.

In order to get some clear idea as to what is the real physiological significance of the menstrual flow, we must consider it in connection with that epoch of special sexual appetite in animals known as *heat* or *rut*, and with the process of ovulation.

The Relationship of Menstruation to the "Heat" of the Lower Animals.—When he says that a female mammal is "in heat" the breeder of cattle and other domesticated animals means that the external generative organs are congested and the female is in a special mental condition which leads her to yield to or to seek the solicitations of the male, which at other times she opposes. In animals which normally breed but once a year (horses, cattle, sheep, deer, etc.) the period of heat occurs in each year at a definite time correlated with the length of pregnancy, so that the young shall be born at a season when food for them and for their mother shall be most abundant. Natural selection, working through heredity, would of course soon establish this relationship. Offspring born at inopportune seasons, when food was scarce, would have less chance of surviving than the offspring of parents born at a more favorable time of the year, and the survivors would, when they became adult, tend to go into heat and to bring forth their young at the same seasons as their parents.

The human race for so many hundreds of generations has been able to provide itself with food and fire at all times of the year that the

[1] *Erfahrungen und Abhandlungen*, Mannheim, 1812.

influence of the seasons in determining a special epoch of sexual appetite might well have been eliminated, even if we assume that it once existed. That it did once exist, and that some remnant of it remains, seem to be indicated by the popular association of spring with the courting of lovers. Tennyson but echoes the general belief when he writes—

> "In the spring the young man's fancy lightly turns to thoughts of love;"

and what is true of the young man is probably true of the young woman. To pass from poets to statisticians, it is found that rather more births occur in the winter than in other months, which tends to indicate some slight excess of sexual appetite or sexual capacity in the spring of the year.

In further considering the relationship of menstruation to "heat" we must bear in mind that unrestrained females of the lower animals almost invariably become impregnated during the period of heat, while the social conditions which prevail in human societies frequently prevent this. Hence it becomes important to inquire what happens in the case of cows, mares, and other animals if copulation does not occur during the period of "heat." If in such cases it is found that the period of sexual exaltation passes off in the female for a time, but recurs after a certain period, it becomes more probable that the periodic recurrence in non-pregnant women of the processes leading to menstruation may be fundamentally the same as those which lead to "heat" in other female mammals.

It has been ascertained by breeders that if the ram be kept from a ewe during her "heat," the sexual appetite and the congestion of the external genitals pass off, but only to recur in about fourteen days; and if sexual congress be then prevented, the ewe is again in heat after a fortnight; and so on. Similar phenomena have been observed in sows, cows, mares, and apes, though the intervals between the periods of heat vary in different animals. At each of these recurring *heat* periods the female is capable of conceiving if sexual congress takes place; hence ovulation is in these animals associated with *heat.*

A special secretion from the uterine mucous membrane of many animals has long been known to occur periodically, and is often combined with slight extravasations of blood on the surface of the membrane (bitch, cow, some bats). In certain apes there is a well-marked bloody discharge at intervals of four weeks. These secretions or discharges are connected with ovulation, which seems to occur mainly toward the end of their period. Buffon found that the bitch would only take the dog six or seven days after the commencement of the period of special uterine activity, and according to Bischoff the egg is discharged normally toward the end of a menstrual flow.

As regards the mammals below man, it may, then, be assumed as well established that uterine activity, resulting in a more or less complete menstruation, is a periodic phenomenon closely associated in time with ovulation; the menstrual processes appearing, however, to rather precede the ovulation.

In most instances, also, ovulation accompanies or immediately precedes heat, but there are well-marked exceptions; in bats, for example, the epoch of heat and copulation precedes by months the processes of ovulation and fertilization. It would therefore appear that ovulation is not necessarily associated with heat or with the uterine changes representing menstruation.

As regards woman, it seems generally admitted that a period of special sexual desire is apt to immediately follow menstruation (Haller, Bischoff, Litzmann). It is also generally believed that while an ovum may be discharged at any time during the years from puberty to the climacteric, yet that normally ovulation is a periodic process having the same rhythm as the menstrual; and this belief seems to be well founded. Whether in each month ovulation precedes menstruation in time, or coincides with or follows it, is still in dispute. We shall later give reasons which make it probable that ovulation occurs usually at or just after the cessation of the menses.

The generally-recognized fact that ovulation and menstruation in woman are rhythmic processes recurring at the same intervals, and more or less closely contemporaneous, has led to a widely-accepted belief that one process depends on or is initiated by the other. It has been assumed either that menstruation reflexly excites the ovaries, or that the ovarian changes resulting in the swelling and bursting of a Graafian follicle irritate ovarian nerves and reflexly excite menstrual changes in the womb. But a third view is possible—namely, that the processes are essentially independent, though they have become in the course of evolution closely associated; and this view seems to the writer the most tenable. It is easy to see how this association might, or indeed must, have originated in time through the process of natural selection.

Assuming for the present, what probably no one doubts, that the uterine changes so conspicuous in the woman as menstruation are in some way connected with the preparation of the womb for the nutrition of the developing embryo (see p. 132), it is clear that the periodicity must give female mammals, who only went through this more or less exhausting process at times when ova were ready for discharge and fertilization, an advantage in leaving descendants. They would have more chance of surviving and of leaving offspring. They would win in the struggle for existence of their race. We have seen also that the changes in the vulva leading to "heat" in the female mammal are in the higher mammals closely associated in time, and probably in causation, with the uterine changes which result in a more or less complete menstrual process. But a continuous sexual heat leading the female mammal to accept or invite the male at all times, even when no ova were ready for fertilization, must be prejudicial to the continuance of the race by leading to a waste of the male reproductive powers.

There would, therefore, be a double advantage in the struggle for existence to any race the females of which were only in heat at times coinciding with the epochs of ovulation, which latter, as we have already seen, is a periodic process. Natural selection must therefore, in the case of the higher animals, almost inevitably bring it about that ovulation and uterine preparation should in the process of evolution come to be closely associated in time even were they, in ancestral forms, quite independent processes.

This close association, continued for generations and always favored by natural selection, would undoubtedly in time lead to secondary connections between the two phenomena, were they originally quite distinct. Ovarian and uterine changes, occurring generation after generation at the same time, would act on the whole physiological working of the organism, and modify it so that when one occurred the other was apt to happen. The ripening of an egg or eggs within the ovary being the primary and essential phenomenon to which preparation of the uterus for its nourishment is secondary, and without which it is not merely useless, but wasteful, it seems obvious that once a causal connection has become established between the two processes, the maturation of the ovum will take the lead; uterine changes will come to depend on it, and not it on uterine changes.

Menstruation, as already pointed out, is a phenomenon strictly comparable to changes which occur in the wombs of many other mammals, though it is only in some of the higher apes and in our own race that it is indicated externally by a conspicuous bloody discharge. Therefore, if the reasoning in the preceding paragraphs be correct, menstruation (= changes in womb fitting it to nourish a fertilized egg) might be expected to be closely associated with ovulation, and in a great majority of cases dependent on it, and excited by the ovarian changes (such as tension) brought about by the swelling and ripening of a Graafian follicle. In other words, preparation with nothing to prepare for would be a sheer waste of energy; and natural selection, working through heredity, has brought it about that menstruation, though primarily quite independent of ovarian changes, has come to be, in the vast majority of cases, determined by them.

That ovulation may and does occur apart from menstruation seems proved by such cases as that of Oldham.[1] In this instance the ovaries had descended into the labia majora, and every three or four weeks

[1] *Proc. Roy. Soc.*, viii. p. 377.

one or both swelled and became tender; the uterus and vagina were absent.

If we accept this view (that there is a secondary acquired, but not primary or necessary, connection between ovulation and menstruation) many puzzling facts are easily explained. There is no doubt that in the human race removal of the ovaries in a great majority of cases leads to cessation of menstruation: that the experience of physicians has led them to a very general acceptance of this belief is evidenced by the considerable number of cases in which the serious operation of oöphorectomy has been performed for the cure of otherwise uncontrollable and dangerous menorrhagia: the correctness of the belief which led to the operation is evidenced by the large number of cures resulting from it. Moreover, the instances in which removal of the ovaries has led to cessation of normal menstruation are so numerous that Hensen[1] says that "no one now takes the trouble to record the cases."

On the other hand, it is well established that women who have never menstruated have borne children: they must have ovulated without menstruating. If, however, we realize that changes in the uterine mucous membrane fitting it to nourish an embryo may take place without any noticeable discharge from the vagina (as in many mammals), there is no difficulty in accounting for such exceptional cases.

Again, Lawson Tait and others have published cases in which menstruation has continued after removal of the ovaries. In some such instances it is probable that the bloody discharge from the uterus was not really menstrual, and in others that the ovaries were not entirely removed. But, making all due allowance for mistakes, it seems indubitable that in a small percentage of women true menstruation continues after complete oöphorectomy. This is just what might be expected if uterine activity be only secondarily associated with ovarian activity. In a certain number of patients menstruation would still manifest its essential independence and the uterus go through the menstrual changes independently of excitation from the ovaries.

The Physiologically-acquired Connection between Ovulation and Menstruation could be easily explained by supposing that a distended Graafian follicle irritated afferent ovarian nerve-fibres, and that these, acting through the spinal cord as a centre, set in action trophic and vaso-dilator nerves going to the womb. But it is quite possible that the association may not be nervous—that it may be due to chemical changes in the circulating liquids of the body brought about by ovarian activity. Goltz[2] has shown that after complete section of the dorsal spinal cord of a bitch, not merely the external symptoms of heat (*e. g.* swelling of the vulvar organs), but also the normal psychical concomitants of ovulation, are present, and that when a bitch with a cut spinal cord becomes

[1] *Hermann's Handbuch*, vol. vi. part 2, p. 71. [2] *Pflüg. Arch.*, vol. ix. p. 552.

pregnant the mammary glands develop in the normal manner. To quote from Foster—[1]

"In the case of a bitch observed by Goltz 'heat' or menstruation took place as usual, though the spinal cord had been completely divided in the dorsal region while the animal was as yet a mere puppy.

"The operation was performed in Dec., 1873. In the following May the animal was in excellent health. . . . . At the end of that month 'heat' came on, attended by all the ordinary phenomena, psychical as well as physical. Impregnation was effected and the animal became gravid. The pregnancy, like the heat, was marked by all the usual signs: the mammary glands enlarged, and the usual mental accompaniments of the condition were present. Finally, one living and two dead puppies were born. . . . . The post-mortem examination showed that there had been no regeneration of the divided spinal cord; the two portions were separated by more than a centimeter.

"In this case the connection between the ovary on the one hand and the mammary gland, brain, etc. on the other, must, if a nervous one, have been furnished by the abdominal sympathetic. We may, however, suppose that the nexus was a chemical one—that the condition of the ovary and uterus effected a change in the blood, which in turn excited the mammary gland to increased action and produced special changes in the brain."

That ovarian changes may profoundly influence almost every organ in the body has long been recognized by physicians, but it has usually been assumed that the influence was excited through the cerebro-spinal nerve-centre. The above-described experiment shows that this is by no means necessarily the case. So far as the local phenomena of "heat" and menstruation are concerned, we must still regard it as an open question whether the ovary influences the womb and external genitals reflexly through the spinal cord or through some other channel. The probability is, however, that the uterine and vulvar changes are spinal reflexes.

The Time Relationships of Ovulation and Menstruation.—That the ripening and swelling of a Graafian follicle normally precede menstruation is hardly open to doubt; but the question whether the follicle bursts and discharges its ovum just before or shortly after menstruation, has been much discussed and perhaps cannot yet be conclusively answered.

In women whose ovaries have taken the normal path of the testes and descended into the *labia majora*, it has been observed that they swell and become tender at periods of about four weeks. In Oldham's case[2]

[1] *Textbook of Physiology*, 3d ed., p. 552.

[2] *Proc. Roy. Soc.*, viii. 377; see also Farre: *Todd's Cyclop.*

the swelling increased for four days; then the size of the organ remained stationary for three days before it commenced to return to its usual bulk. In this patient, however, uterus and vagina were absent; so it gives no clue to the time relationships of menstruation and ovulation. In another published case (Verdier) only the right ovary had descended into the labium and the uterus and vagina were present. The ovary swelled before the onset of the menses, and diminished just after they had ceased. So far as one may draw conclusions from a single instance, it would seem, from this case, that ovarian swelling (due to distension of a Graafian follicle) precedes menstruation, and that ovarian shrinking (due to bursting of the follicle and discharge of the egg) immediately follows it.

Post-mortem examinations of women who have died during or soon after menstruation have rarely been made with proper care, and very few cases are recorded in which an unfertilized egg was properly sought for. Hyrtl[1] records the case of a woman who had menstruated three days before her death, and in whom an ovum was found near the uterine end of a Fallopian tube. Bischoff[2] from 13 cases, in some of which the Graafian follicle was found burst during menstruation, concludes that the time relationships of ovulation and menstruation are subject to considerable variation. Coste found in some cases the egg discharged one day after menstruation, and in others that it was still in the follicle five days after the onset of the menstrual flow.

That ovulation is normally in the human race at present associated with menstruation seems certain, for reasons already stated; also that menstrual changes in its mucous membrane prepare the uterus to receive and nourish the egg. The difference of opinion is whether the uterus is best prepared to nourish the egg when the decidua is developing or after it has been discharged? In other words: Before the menstrual flow has commenced or just after it has ceased?

The Doctrine of His, Reichert, and others is, that the swollen, soft, vascular uterine mucous membrane just before the menstrual discharge commences, is in the best condition for the nourishment of the ovum: therefore ovulation normally occurs before the menstrual flux. If the egg be not fertilized, the mucous membrane disintegrates and is discharged with the menses.

The Doctrine of Pflüger is, that the menstrual uterine changes have the purpose and result of providing a clean or raw surface on which the fertilized ovum may settle and be nourished—that the whole object of menstruation is comparable to that of the surgeon when he pares two surfaces before he brings them in contact with the intention of getting them to grow together. In accordance with this view, menstruation should normally precede ovulation, or at least be completed

[1] *Zeitschrift f. rat. Med.*, New Series, vol. iv. p. 129. [2] *Loc. cit.*

before the ovum has traversed the Fallopian tube and reached the uterus.

The majority of post-mortems on menstruating women accord better with Pflüger's theory, as also do the facts observed (p. 89) on lower animals. It is also in agreement with the usually adopted method of reckoning parturition as due forty weeks from the last menstruation—a method which gives correct results in the great majority of cases.

The strongest arguments in favor of the contrary view are based on the slight development of a number of embryos found (either post-mortem or in cases of abortion) ten days or a fortnight after the first missed menstruation. It is argued that the development of the embryo has so little progressed that it cannot be five or six weeks' old, which it must be if it dated from the end of the last observed menstrual flow, and that therefore conception must have just preceded the expected but missed menstrual flow, and have prevented it. Such arguments are, however, of but little value, as we know that the rate of development of the embryo in its early stages varies greatly in different mammals, and we have at present no data sufficient to enable us to state at what rate the human embryo grows and develops in the first month of its existence.

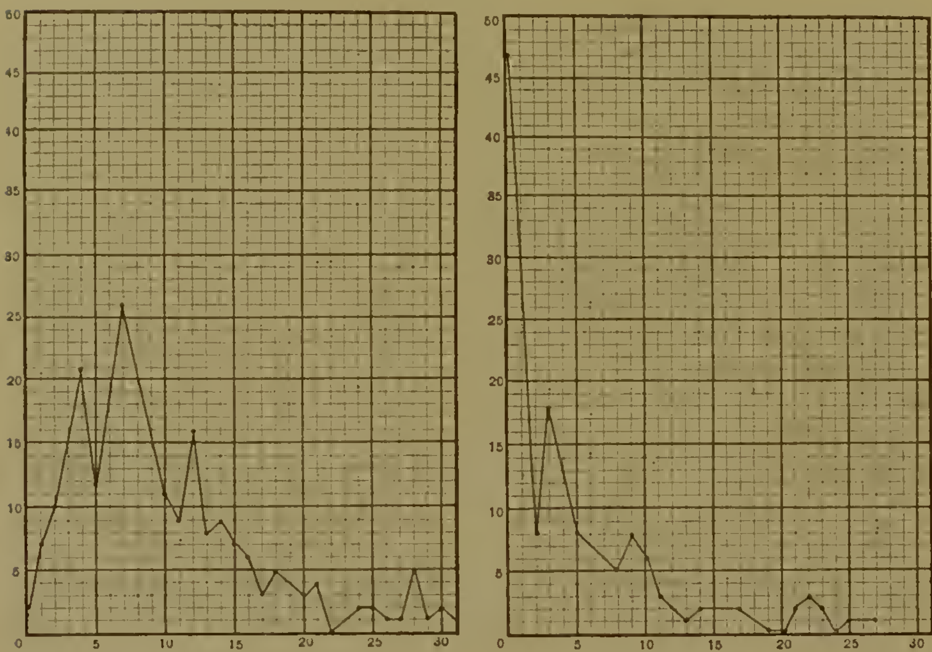
Arguments based on the duration of pregnancy from a coitus known to have been fruitful, to the date of parturition have their value greatly diminished in consequence of the fact that spermatozoa may remain alive and functional for some days within the Fallopian tubes. The older method of reckoning from the first day of the last menstruation gives about two hundred and eighty days as the mean duration of pregnancy. If, however, conception more usually occurs after menstruation, the period of pregnancy must be shorter. Loewenhardt has collected records of 518 cases in which the women could state the date of the coition, and finds, on analyzing them, that the average duration of pregnancy is 272.2 days. Leuchardt collected 67 cases from the marriage-and-birth register of a church. He found the average duration of pregnancy in cases in which a child was born within ten months from the marriage night to be 272.5 days, but that in a considerable number of cases the births were twenty-one days later: these were probably due to conceptions just before the first menstrual period occurring after wedlock, and not just after the menstrual period which preceded it.

Hasler[1] finds, from the comparison of a large number of cases in which the date of coition could be determined, that the mean duration of pregnancy is 280.5 days from the onset of the last menstruation, but 272.24 days from the date of coition. The following curves (Hensen) are based upon 248 cases in which the date of copulation and of menstruation was known :

[1] *Ueber die Dauer der Schwangerschaft*, Zurich, 1876.

The curves show very plainly that the day after the cessation of the menses is by far the most favorable to conception, but they show also

FIG. 12.



Curves showing Relative Frequency of Conception following Coitus at Different Times in relation to Menstruation. In both diagrams the divisions on the abscissa line correspond to days: in the first, to days after the onset of menstruation; in the second, to days after the cessation of menstruation. The curves indicate the proportion of conceptions to copulations on each day of the menstrual month.

that conception may follow coitus at any time in the case of a woman capable of conceiving.

Summary.—We may sum up the facts stated in the present section in a few general statements:

1. Menstruation and ovulation are in the human female closely associated, but are not necessarily mutually dependent processes.

2. In the great majority of cases in the human race ovulation follows menstruation, but the ovarian changes preceding ovulation and producing tension of the ovary reflexly excite the uterus and induce menstruation; and this is completed or nearly completed before the ripe distended Graafian follicle bursts.

3. Ovulation may occur without menstruation, and menstruation without ovulation, but in women this is exceptional.

4. Conception is more apt to result from a coitus immediately after the cessation of the menstrual flow than from sexual connection at any other time.

III. Fertilization of the Ovum.

Fertilization of the Egg, which is the primary fact in *conception,* consists essentially in the fusion of a male pronucleus derived from a spermatozoon with the female pronucleus remaining in the egg after extrusion of the polar bodies (p. 78).

Spermatogenesis.—The study of the development of the spermatozoa shows that each one is the morphological equivalent of a cell. The *head* of the spermatozoon is a cell-nucleus imbedded in a thin layer of cell-protoplasm; the tail is a *cell-body* specialized to form a motile organ or cilium.

Just as in the ripening of the ovum some of the matter of the mother-cell is separated in the polar globules, so in the development of spermatozoa some of the material of the mother-cell (or *spermatoblast*) is cast off as the *seminal granule* or *accessory corpuscle.* If we accept the view of Minot and Balfour, that the polar globules represent the male element in the primitive egg-cell, which is eliminated in order to make cross-fertilization possible, we may explain the accessary corpuscle of the developing spermatozoon as representing the female element of a primitive reproductive cell, extruded in order that the residue (spermatozoon) may be unable to reproduce by itself, but be fitted to fuse with a ripe ovum and give rise to a new compound cell, the *oosperm,* due to the fusion of living matter from two individuals, and ready to segment and develop into a new animal.

The formation of the accessory globule is not confined to animals: it is very conspicuous in many plants which produce motile *antherozooids* (*e.g.* ferns: see Fig. 253 in Sach's *Textbook of Botany,* English translation, 1875, p. 343).

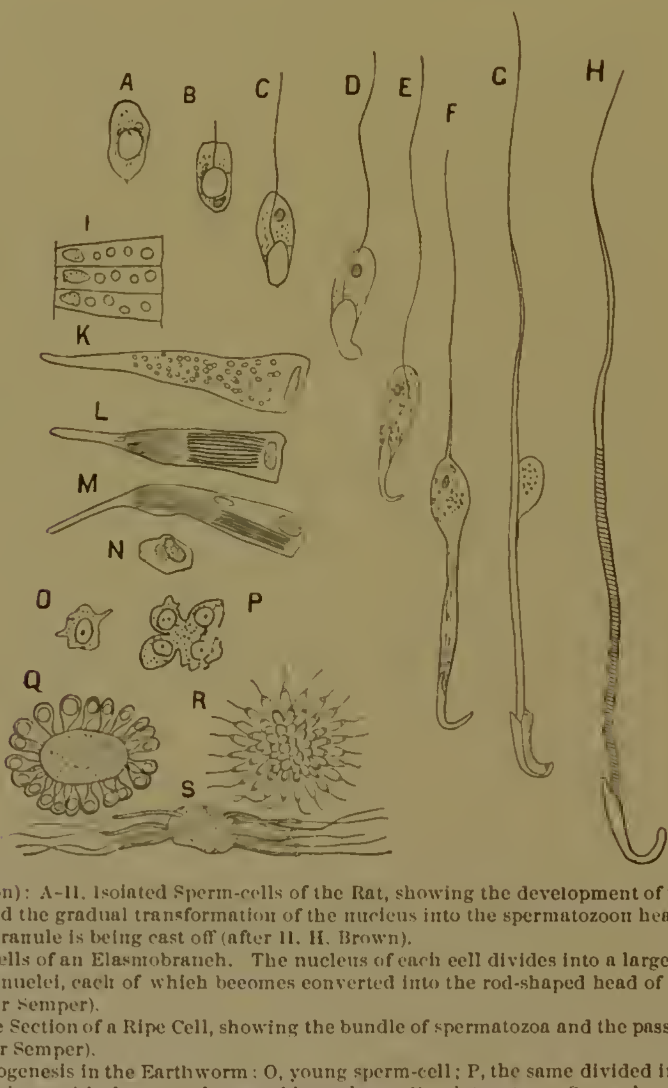
The development of spermatozoa differs much in detail in various groups of animals: they arise, however, in all cases from primitive generative cells, which are in the embryo apparently quite like the cells of the generative epithelium (p. 195) which give rise to ova in the female sex. The process starts with "germinal cells" which are of no sex: later, in some individuals these give origin to ova, in others to spermatozoa. To quote from Haddon:[1] "The primitive sperm-cells or mother-cells of the spermatozoa arise from a tissue corresponding to that which gives rise to the primitive ova. The exact manner in which the spermatozoa are developed varies in different animals, and has been variously described by numerous investigators. This being the case, it will be advisable to give simply a sketch of what appear to be the most important facts in spermatogenesis.

"Those cells of the generative epithelium [of the embryo, see p. 195] which develop into male sexual cells undergo cell-division in the ordi-

[1] Haddon: *Introduction to the Study of Embryology,* 1887, p. 11.

nary manner, and may give rise to a considerable number of *spermatoblasts.* Each spermatoblast gives rise to a spermatozoon, and in doing so gives [off] a small mass of protoplasm, the so-called *seminal granule* or *globule* or *accessory corpuscle,* which appears to have no further function. Fig. 13, A–H, illustrates this process in the rat.

FIG. 13.



(From Haddon): A–H, Isolated Sperm-cells of the Rat, showing the development of the spermatozoon and the gradual transformation of the nucleus into the spermatozoon head. In G the seminal granule is being cast off (after H. H. Brown).

I–M, Sperm-cells of an Elasmobranch. The nucleus of each cell divides into a large number of daughter-nuclei, each of which becomes converted into the rod-shaped head of a spermatozoon (after Semper).

N, Transverse Section of a Ripe Cell, showing the bundle of spermatozoa and the passive nucleus (I, N, after Semper).

O–S, Spermatogenesis in the Earthworm: O, young sperm-cell; P, the same divided into four; Q, spermatophore with the central sperm-blastophore; R, a later stage; S, nearly mature spermatozoa (after Blomfield).

"Instead of becoming distinct, the spermatoblasts or incipient spermatozoa may remain aggregated together (*spermosphere* or *sperm-morula*) and surround a central non-nucleated protoplasmic mass (the *sperm-blastophore*), as in the case of the snail and earthworm (Fig. 13, O–S).

"In Elasmobranchs [sharks, dog-fishes, rays], Fig. 13, I–N, the nucleus of the sperm-cell alone divides, forming a number of daughter-nuclei, the remains of the parent-nucleus still persisting. The protoplasm of the cell differentiates into the tails of the spermatozoa, while the daughter-nuclei constitute their heads. The ripe spermatozoa are liberated by the rupture of the wall of the sperm-cell, leaving behind the remains of parent-nucleus and a small remnant of unused protoplasm. This is merely an abbreviated variation of the [process in the snail and earthworm]: the residual nucleus and protoplasm clearly correspond to the accessory corpuscle or sperm-blastophore in the preceding forms.

"The nucleus of each daughter sperm-cell constitutes the head of a spermatozoon; it is surrounded by an extremely delicate film, which is produced at one end into a fine flagellum, and sometimes, also, into an almost imperceptible undulating membrane. [The enclosing film, the flagellum, and the membrane] are formed by the [extra-nuclear] protoplasm of the spermatoblast. Every spermatozoon is thus a true morphological cell."

Observations on the lower animals show that normally but one spermatozoon fertilizes an egg. Many may collect around it, and even penetrate its coverings, but only one enters the egg-protoplasm and is efficient in its fertilization.

It is probable that once the spermatozoa have reached the neighborhood of the ovum their movements are controlled by some substance excreted by the egg and diffused in the liquid bathing it. In some of the lower plants (ferns and others) the male elements are motile *antherozooids:* if a capillary tube containing a weak solution of malic acid be immersed in a water containing antherozooids, the latter swim toward the opening of the tube. The malic acid, slowly diffusing through the water, controls the movements of the antherozooids, so that their cilia lash in a manner tending to drive them to the place where there is most malic acid. It has also been found that malic acid is excreted by the female organs of these plants. Some similar process may occur in the higher mammals and lead to a swarming of spermatozoa around the egg.

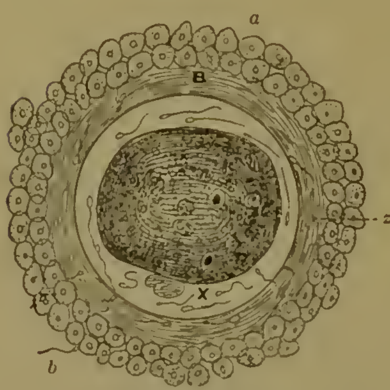
Barry[1] was the first who described spermatozoa within the zona pellucida of the mammalian ovum. His observations, made on the rabbit, have been confirmed, more than twenty spermatozoa having been seen within the egg-case by Hensen.

According to Hensen's observations on the rabbit, the spermatozoa begin to penetrate the zona pellucida about thirteen hours after coitus. The cells of the discus proligerus have by this time undergone a mucous degeneration, and the vitellus has shrunk somewhat (from the expulsion of liquid), and has given off the polar bodies. Some of the spermatozoa enter the zona obliquely, and these never get through it; others

[1] *Phil. Trans. Roy. Soc.*, 1843.

enter it perpendicularly, and bore their way into the space between the contracted ovum and the zona (Fig. 14). One of them enters the egg-protoplasm, and its head or nucleus may for a time be seen as the *male pronucleus;* this approaches the female pronucleus, and the two fuse to form the *segmentation nucleus* of the fertilized egg, which latter is henceforth named the *oosperm.* From this fertilized cell, made up of food-materials stored in the vitellus, of protoplasm of the egg mingled with protoplasm from the tail of the spermatozoon, and of a nucleus resulting from the fusion of the head of the spermatozoon (male pronucleus) with the residue (female pronucleus) of the germinal vesicle of the ovum, the fœtus with all its tissues and organs is developed by cell-multiplication and cell-modification.

FIG. 14.



A Rabbit's Egg being Fertilized (Hensen): *a*, cells of the discus proligerus; *z*, zona pellucida. At *b*, on the lower left-hand part of the figure, a spermatozoon is seen beginning to make its way between the cells of the discus proligerus. Several spermatozoa are seen imbedded in the zona pellucida, the majority of them obliquely placed with reference to a diameter of the ovum. The yelk has contracted and given off the polar globules. Many spermatozoa which have bored their way vertically through the egg membranes are seen in the space between the vitellus and the zona pellucida. At *x* is seen the remnant (*male pronucleus*) of the head of a spermatozoon which has penetrated the vitellus.

The Origin of Tissues and Organs by Differentiation. — The fertilized egg divides into a number of cells: these, at first alike, arrange themselves into groups, and, continuing to multiply by division, give rise to cells which grow in many different ways and assume characteristic microscopic forms. Some elongate into fibres, others remain more or less rounded; some excrete around them a large amount of intercellular substance and make cartilage, bone, and connective tissue; others make little intercellular substance. In some the contractility of the original egg-protoplasm is intensified and they become muscle-fibres. Others become so modified in structure that they almost or quite lose the contractile power possessed by the ovum, but develop to a high degree its *irritability*, or faculty of being easily changed by external influences: they become nerve-cells or the end-organs of nerve-fibres in the retina and other sense apparatuses. Some cells become distinctly secretory, others excretory; some become horny, and as epidermis, hairs, and nails serve to protect the organism. The general result is that from a set of similar cells, formed by the division of a single cell, the *oosperm,* there is developed that heterogeneous mass of groups of cells, each with distinctive modes of growth and with special physiological properties, which constitutes the tissues and organs of the adult human body.

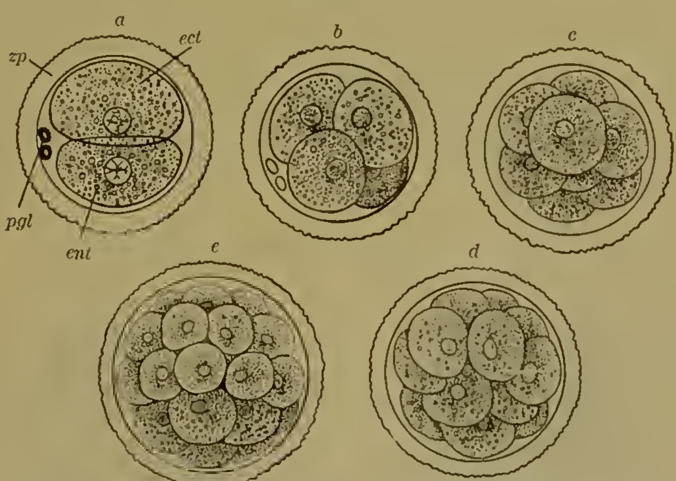
IV. The Early Stages of Development.

The Segmentation of the Fertilized Ovum (*Oosperm*) has not been directly observed in human eggs; it probably does not differ much from the same process in the rabbit, a knowledge of which we chiefly owe to the valuable researches of Ed. van Beneden.[1] We cannot do better than quote the summary of Van Beneden's results as given by Balfour[2] (words in square brackets are interpolated):

The protoplasm of the oosperm "first divides into two nearly equal spheres (*a*, Fig. 15), of which one is slightly larger and more transparent than the other. The larger sphere and its products will be spoken of as the [*epiblastic*] spheres, and the smaller sphere and its products as the [*hypoblastic*] spheres, in accordance with their different destinations." [The cells which result from the division of the ovum, and have not yet been specialized to form particular layers of the embryo are named "blastomeres."]

"Both the spheres are soon divided into two, and each of the four

Fig. 15.



First Stages of the Segmentation of a Mammalian Ovum (rabbit) (from Allen Thomson, after Ed. v. Beneden's description): *zp*, zona pellucida; *pgl*, polar globules; *ect*, first epiblast cell; *ent*, first hypoblast cell; *b*, stage of four blastomeres; *c*, eight blastomeres, the *epiblast* cells partially enclosing the *hypoblast* cells; *d*, and *e*, later stages of segmentation, showing the more rapid multiplication of epiblast cells and the gradual surrounding by them of the hypoblast cells.

so formed into two again (Fig. 15, *b*), and thus a stage with eight spheres ensues (Fig. 15, *c*). At the moment of their first separation these spheres are spherical and arranged in two layers, one of them

[1] "Développement embryonnaire des Mammifères," *Bull. de l'Acad. Belgique*, 1874; "La Maturation de l'Œuf, la Fécondation et les premières Phases du Developpement embryonnaire des Mammifères," 1875; "Recherches sur l'Embryologie des Mammifères," *Archives de Biologie*, 1880.

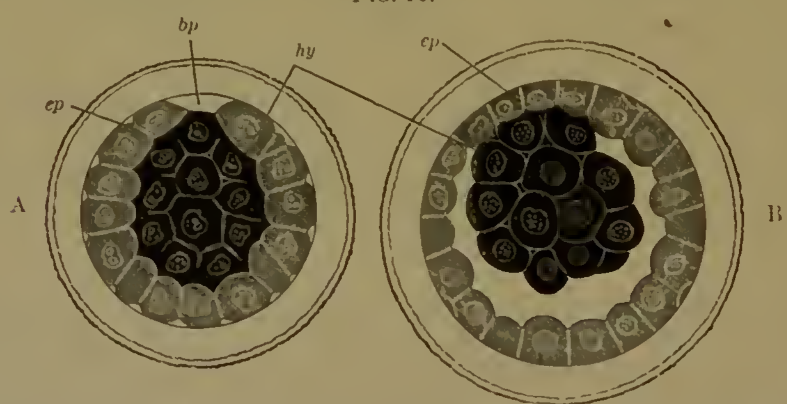
[2] *Elements of Embryology*, by Foster and Balfour, 2d ed., 1883, p. 313.

formed of the four epiblastic spheres and the other of the four hypoblastic. [The embryo is therefore at this time somewhat flattened.] This position is not long retained, but one of the hypoblastic spheres passes to the centre, and the whole ovum again takes a spherical form.

"In the next phase of segmentation each of the four epiblastic spheres divides into two, and the embryo thus becomes constituted of twelve spheres, eight epiblastic and four hypoblastic. The epiblastic spheres have now become markedly smaller than the hypoblastic (Fig. 15, *d*).

"The four hypoblastic spheres next divide, giving rise, together with the eight epiblastic spheres, to sixteen cells in all, which are nearly uniform in size. Of the eight [hypoblastic] spheres, four soon pass to the centre, while the eight superficial [epiblastic] spheres form a kind of cup partially enclosing the [hypoblastic] spheres (Fig. 15, *e*). The [epiblastic] spheres now divide in their turn, giving rise to sixteen spheres, which largely enclose the [hypoblastic] spheres. The segmentation of both [epiblastic and hypoblastic cells] continues; in the course of it the epiblastic spheres spread farther and farther over the hypoblast, so that at the close of segmentation the hypoblast spheres constitute a central solid mass almost entirely surrounded by the epiblast spheres. In a small circular area, however, the hypoblast spheres remain for some time exposed on the surface (Fig. 16, A, *bp*).

Fig. 16.



Optical Sections of an Oosperm of a Rabbit, at two stages closely following upon segmentation (from Balfour, after Ed. v. Beneden): *ep*, epiblast; *hy*, primary hypoblast; *bp*, the opening in the epiblastic layer at one point, named blastopore by E. van Beneden: this is not a true blastopore. The shading of the epiblast and hypoblast is diagrammatic.

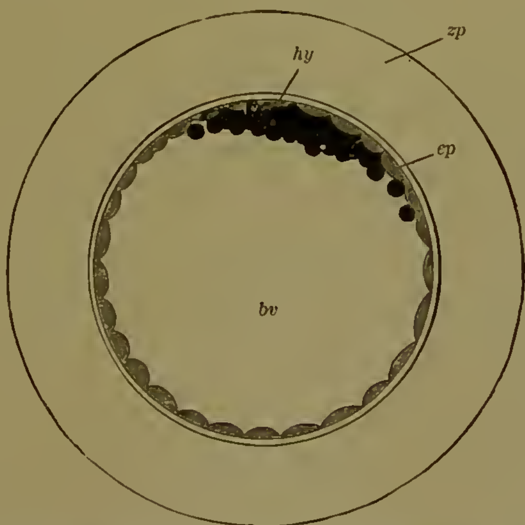
"The whole process of segmentation is completed in the rabbit about seventy hours after impregnation. At its close the *epiblast cells*, as they may now be called, are clear and have an irregularly cubical form, while the *hypoblast cells* are polygonal and granular, and somewhat larger than the epiblast cells."

[The developing oosperm at the close of segmentation is named the *morula* or mulberry mass.]

"After its segmentation the [oosperm] passes into the uterus. The epiblast cells soon grow over the blastopore [of Van Beneden, which is merely an uncovered part of the hypoblast], (*bp*, Fig. 16, A), and thus form a complete superficial layer.

"The succeeding changes commence with the appearance of a narrow cavity between the epiblast and hypoblast, which extends so as to completely separate these two layers, except in the region adjoining the original site of the [uncovered portion of the hypoblast], (Fig. 16, B). The cavity so formed rapidly enlarges, and with it the ovum also, which soon takes the form of a thin-walled vesicle with a large central cavity. This vesicle is the *blastodermic vesicle*. The greater part of its walls is formed of a single row of flattened epiblast cells, while the hypoblast cells form a small lens-shaped mass attached to the inner side of the epiblast cells (Fig. 17).

Fig. 17.

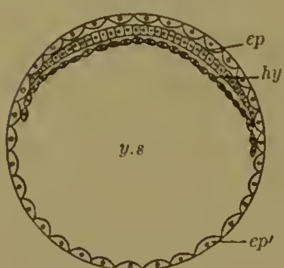


Rabbit's Ovum between Seventy and Ninety Hours after Impregnation (after E. van Beneden): *bv*, cavity of blastodermic vesicle or yelk-sac; *ep*, epiblast; *hy*, primitive hypoblast; *Zp*, layer formed by zona pellucida and swollen and degenerated cells of discus proligerus.

"Although by this stage, which occurs in the rabbit between seventy and ninety hours after impregnation, the blastodermic vesicle has by no means attained its greatest dimensions, it has nevertheless grown from about 0.09 mm. ($\frac{1}{250}$ inch)—the size of the morula at the close of segmentation—to about 0.28 mm. ($\frac{1}{90}$ inch) in diameter. It is enclosed by a membrane formed from the zona radiata and the mucous layer around it. The blastodermic vesicle continues to enlarge rapidly, and during the process the hypoblastic mass undergoes important changes. It spreads out on the inner side of the epiblast, and at the same time loses its lens-like form and becomes flattened. The central part of it, however, thickens, and becomes constituted of two rows of cells, while the peripheral part, the outer boundary of which is irregular, is formed of an imperfect layer of amœboid cells, which continually spread farther and farther within the epiblast. The central thickening of the hypoblast forms an opaque circular spot on the blastoderm, which constitutes the commencement of the *embryonic area*."

The structure of the developing ovum at this stage is diagrammatically represented in Fig. 18. It is three layers thick in the embryonic area. The outer cells at this region, derived from the primitive epiblast layer, are known as the *cover-cells*. They do not directly share in the formation of the embryo. The rest of the primitive epiblast (non-embryonic epiblast, *ep'*) helps to form the amnion and umbilical vesicle. (See p. 126.) The second layer of cells in the embryonic layer, *ep*, becomes the *epiblast* of the embryo proper; the innermost layer is the *hypoblast* proper (*hy*). The covering cells soon disappear, so that the embryonic epiblast becomes superficial. Whether the cover-cells fuse into it and help to form it, or are used in forming the fœtal membranes, is not known. Later on we shall find that in the embryonic area a third layer of cells, the *mesoblast*, develops between the hypoblast and the embryonic epiblast; but before proceeding further with the account of the development of the mammalian it is desirable to consider briefly the corresponding processes in the hen's egg, as only then can certain of the phenomena observed in Mammalia be properly understood.

FIG. 18.



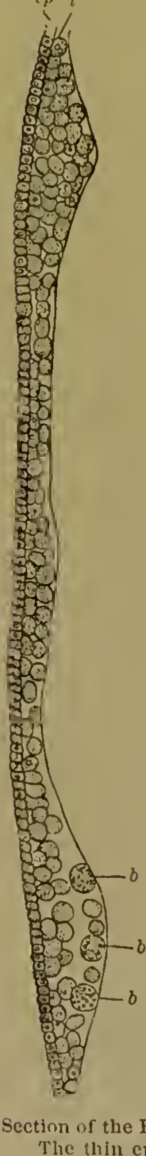
Diagrammatic Section of a Mammalian Blastoderm after the cover-cells have completely closed in the blastoderm, and the embryo proper has become two-layered: *ep'*, non-embryonic epiblast; *ep*, embryonic epiblast; *hy*, hypoblast; *y.s*, yelk-sac. (From Haddon.)

The Early Stages of the Development of the Chick.—The egg of the now existing higher mammals (*Eutheria*), though holoblastic itself, is undoubtedly descended from an egg which was mesoblastic and possessed a considerable quantity of food-yelk. In its present development it still gives evidence of this ancestral condition.

The egg of a hen consists of certain accessory structures—shell, shell-membranes, and white—and of the egg proper, consisting of the yelk and *vitelline membrane*. The latter corresponds to the zona radiata of the mammalian ovum. Most of the yelk is mere food-material, but on one side of it (which always comes uppermost if the fresh egg be laid on one side for a few minutes) is a special collection of germ-yelk, forming the so-called *germinal disk*. In it, before the egg is quite matured in the ovary, can be found the germinal vesicle and germinal spot: from it are extruded, as it matures, polar bodies, essentially as in the mammal's ovum. The white, shell-membranes, and shell are added to the ovarian egg, or egg proper, as it descends through the oviduct.

The seminal fluid of the cock fertilizes the egg as it leaves the ovary; its passage from this spot to the exterior takes from fifteen to twenty hours, and during this time the earliest stages of development—namely, the segmentation of the ovum—are passed through. The further progress of development is then checked unless the egg be kept warm. Segmentation is confined to the region of the germinal disk, which region is known as the *upper pole* of the egg. Lying just under the vitelline membrane at this point we find, in a fresh-laid fertilized egg, a flat membrane resulting from the segmentation, and named the *blastoderm.*

FIG. 19.



Structure of the Blastoderm of a Fresh-laid Fertilized Hen's Egg.—Section through the blastoderm at this period shows it to have the structure represented in Fig. 19. It consists essentially of two layers of cells. The upper forms a coherent membrane, and is the epiblast, *ep.* The cells of the lower layer, *l*, are rounded and irregularly arranged, not forming a continuous layer. Beneath them lies the food-yelk (not represented in the figure).

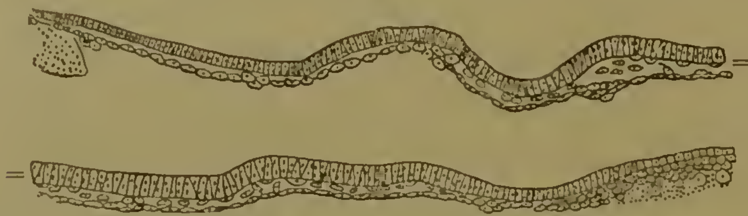
The Growth of the Blastoderm of the Chick.—As soon as incubation commences the cells of both blastodermic layers multiply by division. In addition, the lower layer is constantly joined by new cells derived from some protoplasm previously scantily diffused throughout the mass of food-yelk. These cells creep up and add themselves to the lower layer, especially near its outer margin. They are called *formative cells* (*b*, Fig. 19). The blastoderm is at first circular in outline and about the diameter of a silver half-dime, but as the number of its cells increases it spreads farther and farther around the food-yelk, which it ultimately completely envelops.

After a few hours of incubation (five or six) most of the lower cells become flattened and join by their edges to make a continuous layer (Fig. 20), the *hypoblast.* Between the hypoblast and epiblast are shut in a few irregularly-shaped cells from the primitive lower layer and from some of the formative cells. They are the first indications of an intermediate layer of the blastoderm, which ultimately becomes highly developed—namely, the *mesoblast.*

Section of the Blastoderm of a Fowl's Egg at the Commencement of Incubation (from Balfour). The thin epiblast, *ep*, composed of columnar cells, rests on the incomplete lower layer, *l*, composed of larger and more granular hypoblast cells; this layer is especially thick at the periphery. The line below the hypoblast marks the upper surface of the food-yelk.

A surface view of the blastoderm at this stage presents a more transparent central circular portion, the *area pellucida*, surrounded by a

Fig. 20.

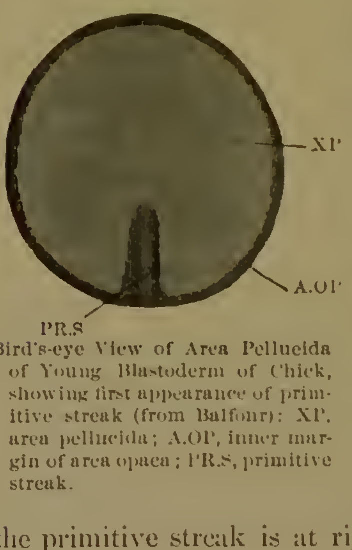


Vertical Section through the Blastoderm of the Chick after a Few Hours' Incubation (from Balfour). The epiblast is represented somewhat diagrammatically. The hyphens show the points of junction of the two halves of the section.

more opaque rim, the *area opaca*. As incubation proceeds and the blastoderm spreads over the yelk both areas increase in size. *It is in the area pellucida that the embryo develops.*

The Non-embryonic Portion of the Blastoderm.—The large food-yelk of the hen's egg, which, with the white, has to be absorbed and utilized for the nourishment of the embryo, necessitates an extension of the blastoderm far beyond the region in which the embryo itself is formed. This is the *non-embryonic* portion: it gives rise to accessory fœtal structures—the *yelk-sac* and *the amnion.*

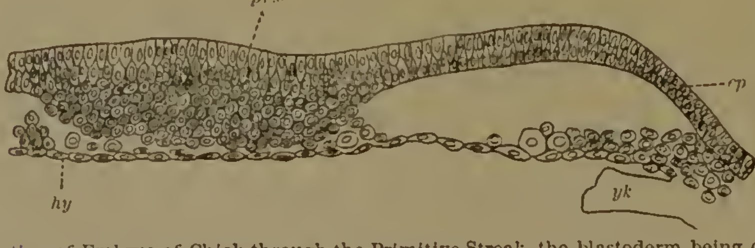
Fig. 21.



Bird's-eye View of Area Pellucida of Young Blastoderm of Chick, showing first appearance of primitive streak (from Balfour): XP, area pellucida; A.OP, inner margin of area opaca; PR.S, primitive streak.

The Primitive Streak and Groove.—After twelve hours of incubation, when the whole blastoderm is not larger than a dime, surface views disclose a slight opacity in one portion of the area pellucida (Fig. 21). This opacity is the *primitive streak.* Sections show that it is due (Fig. 22) to a great thickening of the mesoblast in this region, caused by multiplication of epiblast cells. The long axis of the primitive streak is at right angles to the long axis of the egg, but

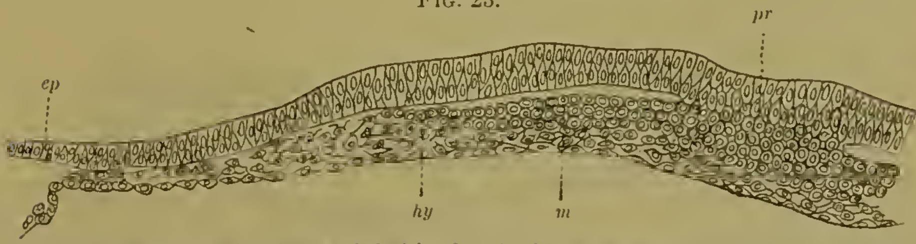
Fig. 22.



Cross-section of Embryo of Chick through the Primitive Streak, the blastoderm being of about the same age as that represented in Fig. 21 (from Balfour). The section passes across the middle of the primitive streak; *pr.s*, primitive streak; *cp*, epiblast; *hy*, hypoblast.

coincides with the long axis of the future embryo. The embryo, however, develops entirely in front of the primitive streak, the front end

FIG. 23.



Vertical Transverse Section through Primitive Streak of Developing Hen's Egg, after the lateral outgrowths of the mesoblast have commenced: *pr*, primitive streak and commencing primitive groove; *m*, mesoblast; *ep*, epiblast; *hy*, hypoblast (from Balfour. Most of the right half of the section is omitted, the middle line of the blastoderm being at *pr*).

of which corresponds to its tail end. Along its axis the mesoblast of the primitive streak remains for some time continuous with the epiblast: but its cells multiply and spread laterally (Fig. 23, *m*), and there form a separate layer. After about sixteen hours of incubation the area pellucida is seen to have increased considerably in size and to have become pear-shaped. Along its axis appears a superficial furrow, the primitive groove (*pr*, Fig. 24).

FIG. 24.

Surface View of Blastoderm of Chick after the Primitive Groove has been Formed (from Balfour): *pr*, primitive streak, with primitive groove; *af*, amniotic fold. The slightly darker shading around the primitive streak indicates the lateral extension of the mesoblast in this region.

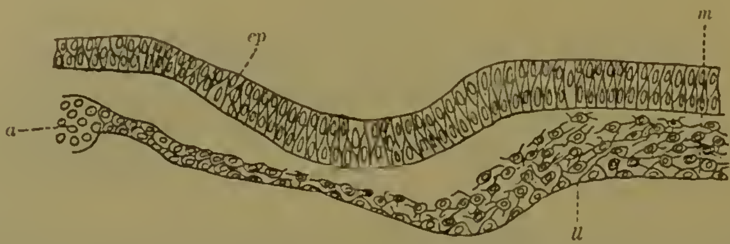
The primitive groove and streak are transient structures in the chick, and are only explicable as due to heredity from ancestral forms. Comparative embryology has, in fact, afforded a satisfactory explanation of them, but it would take us too far afield to enter upon it here.[1]

The Formation of the Mesoblast in Front of the Primitive Streak.—In the anterior portion of the area pellucida the mesoblast has a very different origin. Some of it is derived from formative cells, but most of it is formed by multiplication of the cells of the hypoblast. These divide and give off, into the space between them and the epiblast, a number of irregularly branched cells, at first along the line of the long axis of the future embryo (Fig. 25). From this axis the mesoblast spreads as a distinct layer on each side (Fig. 26), but its continuity with the hypoblast along this axis remains for some time (*ch*), and there its cells soon become rounded and closely packed.

[1] See Haddon: *Introduction to Embryology*, p. 41.

The Formation of the Notochord.—Next (after about eighteen hours of incubation) there occurs a fact of fundamental importance. The

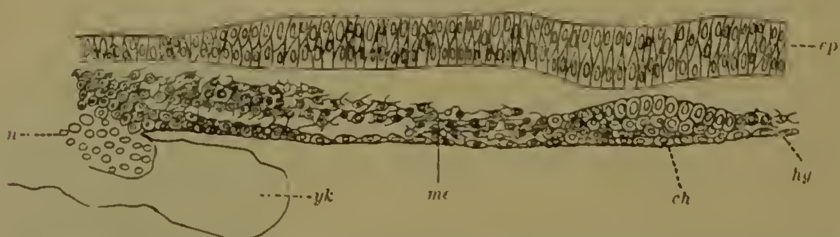
Fig. 25.



Part of Transverse Vertical Section through the Embryonic Region of the Area Pellucida of a Chick, shortly before the formation of the medullary groove and notochord: *m*, median line of section; *ep*, epiblast; *ll*, lower layer cells (primitive hypoblast) not yet quite differentiated into mesoblast and hypoplast. (From Balfour.)

mesoblast cells in the embryonic area separate from the hypoblast along the antero-posterior axis of the future chick (Figs. 26, 27, *ch*), and form a

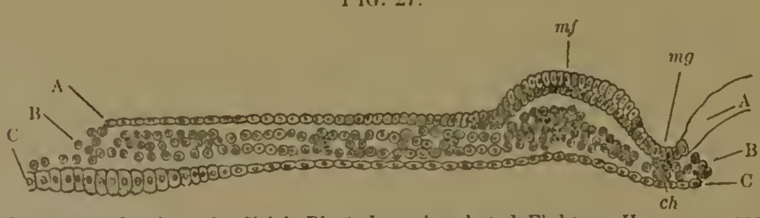
Fig. 26.



Transverse Vertical Section through the Embryonic Region of the Area Pellucida at the time of the first appearance of the notochord, but after the mesoblast and hypoblast have become differentiated in the lateral parts of the embryo (from Balfour): *ch*, commencing notochord and middle of section; *ep*, epiblast; *hy*, hypoblast; *me*, mesoblast.

distinct cellular rod, the *notochord*. This is the earliest developmental fact which plainly indicates that the embryo is that of a vertebrate

Fig. 27.



Half of Transverse Section of a Chick Blastoderm incubated Eighteen Hours: *mg*, medullary groove and middle line of section: A, epiblast; B, mesoblast; C, hypoblast; *mf*, medullary fold; *ch*, notochord.

animal. In the bird and mammal the spinal column and part of the base of the skull are built up around the notochord. As shown in the figure, the plates of mesoblast on the sides of the notochord are separated from it by a space containing only liquid. They are known as the *peripheral plates*.

The Tissues and Organs developed from Each of the Three Primary Layers of the Blastoderm.—The three fundamental layers of the blastoderm may now be regarded as definitely established in the embryonic area. All three will spread as the blastoderm grows and help to form fœtal appendages developed from the non-embryonic area. But, so far as the definite building of the body of the future chick is concerned, we find that in it, as in all the higher animals, each layer gives origin to certain definite tissues and organs, to these and to no others—a fact of profound importance morphologically and physiologically.

In the higher vertebrates the following structures are always derived from the *epiblast*—namely, epidermis; epithelium of mouth, epithelium of nose, and epithelium of cloaca (when present); the nerve-cells of brain, spinal cord, and ganglia; their branches, the axis-cylinders of all nerve-fibres; the neuroglia or supporting tissue of the nerve-elements in the brain and spinal cord; the retina; the lens of the eye; epithelium of the conjunctiva; the special sensory "end-organs" of nerve-fibres in ear, nose, mouth, and skin.

From the *hypoblast* are derived the cells lining the alimentary canal (except the buccal cavity and cloaca); the secreting cells of the digestive glands and the cells lining their ducts; the epithelium of the lungs and air-passages, except the nares.

From the *mesoblast* develop all the tissues of the internal skeleton, bony, cartilaginous, connective; the heart and blood-vessels; the lymphatics; the muscles; the reproductive glands; and the kidneys.

Embryology shows that the mesoblast is later in development than either of the other layers, and is derived from them, and, though so important in the higher animals, is secondary in its origin. Comparative anatomy in this respect agrees in its testimony with embryology. The simpler multicellular animals (Metazoa), such as the fresh-water hydra and its allies, consist of but two fundamental layers of cells, the ectoderm and endoderm, which correspond to epiblast and hypoblast respectively. The hydra is a mere two-layered sac: its outer-layer cells are essentially protective, motor, and sensitive, and place it in relation with its environment. Corresponding to this we find in higher animals (all of which pass through a two-layered stage in their development) that the nervous system and the essential parts of the sense-organs are epiblastic in origin. The endoderm cells of hydra, which line its cavity, are essentially nutritive cells; they secrete digestive liquid and they absorb the products of digestion. Corresponding to this fact, we find that the cells of the digestive glands and the absorbent cells of the alimentary tract are derived from hypoblast. In the course of evolution from a primitive two-layered ancestor the mesoblast has been developed, partly from each of the other layers: they have relegated to this third layer such functions as do not imply immediate contact with the environment or with food-materials; so the mesoblast has come to form the supporting tissues, the motor organs, and the organs for distributing absorbed nourishment and oxygen; for preparing sexual cells; for separating wastes from the blood to be transferred to the exterior, usually through passages, in part at least, still lined by epiblast.

The Gastrula Theory.—The theory that the two-layered stage through which all the higher animals pass in the course of their development is an inheritance from a simpler ancestral form which never possessed more than two layers of cells, is known as the *gastrula theory,* and is generally accepted by biologists.

The Formation of the Medullary Folds and Groove.—At about the time when the notochord is formed the epiblast is found to have become (Fig. 27) two or more layers of cells thick on each side of that structure. A similar thickening occurs in front of the notochord. These thickenings give rise to two ridges which run parallel to one another along the sides of the anterior portion of the notochord and converge and meet in front of it (Fig. 28). These ridges are the beginnings of the *medullary folds*, and the trough between them is the *medullary groove.* The folds at first diverge behind and embrace between them the front end of the primitive groove; but they soon converge again (Fig. 29) and

FIG. 28.

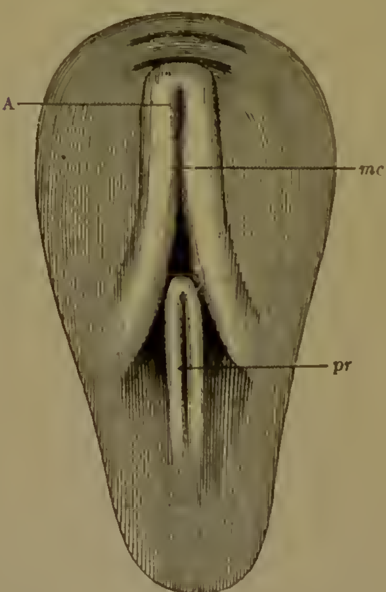


FIG. 29.

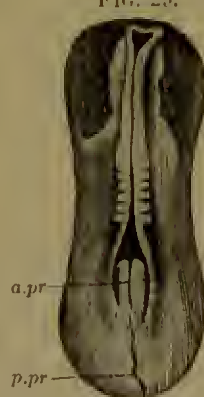


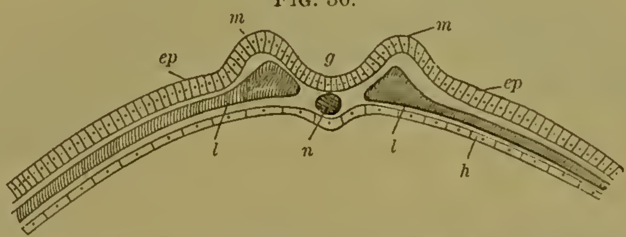
FIG. 28.—Bird's-eye View of the Area Pellucida of a Hen's Egg after Incubation for Eighteen Hours (from Balfour). None of the area opaca is shown, the pear-shaped outline indicating the limits of the pellucid area. At the posterior end of the pellucid area is seen the primitive groove, *pr*. In front of the primitive groove is seen the medullary groove, *mc*, bounded by the medullary folds, A. The dark curved line in front of the medullary groove indicates the head-fold; the concentric dark line a little in front of it is the commencing amniotic fold.

FIG. 29.—Dorsal View of the Embryonic Area of the Blastoderm of the Hen's Egg, after the medullary folds have arched over and met for a great part of their extent, but not yet fused together: *a.pr*, anterior part of primitive groove: *p.pr*, remnant of posterior part of primitive groove. The anterior divergence of the medullary folds indicates that portion of them which will ultimately give origin to the fore-brain (from Balfour).

meet a little way behind the front of the primitive groove. They then quickly approximate at the region where they formerly spread apart, so that the neural groove is converted into a narrow trough closed in front and behind, and bounded by epiblastic elevations on each side.

A cross-section of an embryo at this stage, in the region which is ultimately to form the dorsal region of the chick, would show the structure diagrammatically represented in Fig. 30.

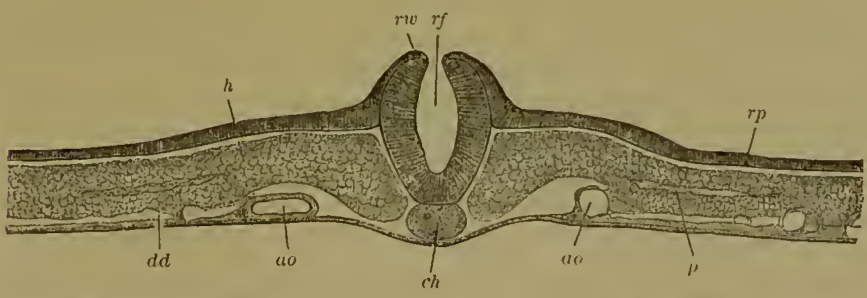
FIG. 30.



Cross-section of an Embryo in the Dorsal Region soon after the first appearance of the medullary folds (diagrammatic): *g*, medullary groove; *m*, *m*, medullary folds; *n*, notochord; *l*, peripheral plates of mesoblast; *ep*, epiblast; *h*, hypohlast. (The shading of the figure is very diagrammatic.)

In Fig. 31 is represented a later stage of development. The medullary folds have risen higher and begun to bend over toward one another.

FIG. 31.



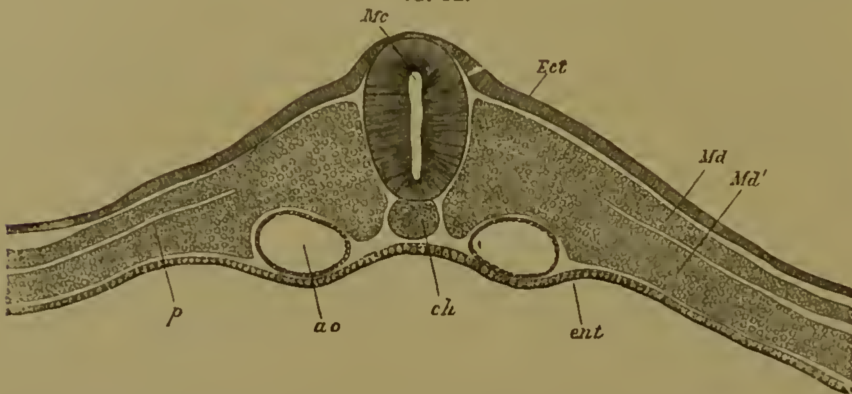
Cross-section of a Chick Embryo in the Dorsal Region, after a few more hours' incubation than the embryo represented diagrammatically in Fig. 30 (from Kölliker; magnified 83 diameters): *rf*, medullary groove closing in; *rw*, medullary fold; *h*, epiblast; *ch*, notochord; *rp*, peripheral plates of the mesoblast; *dd*, hypoblast; *ao*, aortic arch; *p*, commencing slit in mesoblast which separates it into somatopleuric and splanchnopleuric layers.

A little later (Fig. 32) they meet, and their edges fuse in the middle line. The medullary groove is thus converted into the medullary tube or *neural canal*, which is lined by epiblast. Very soon the epiblast covering in the tube separates as a distinct layer from that lining the canal, though for some time the two remain in contact, as shown in Fig. 32.

The folds first meet (Fig. 29) near their anterior ends, in what subsequently becomes the posterior part of the head region of the chick. From this point the closure of the canal rapidly proceeds forward, and more slowly backward, so that the groove is open toward the tail for some hours after it has been closed anteriorly.

From the epiblast lining the neural canal are developed the brain, retina, spinal cord, the axis-cylinders of all the nerve-fibres, and

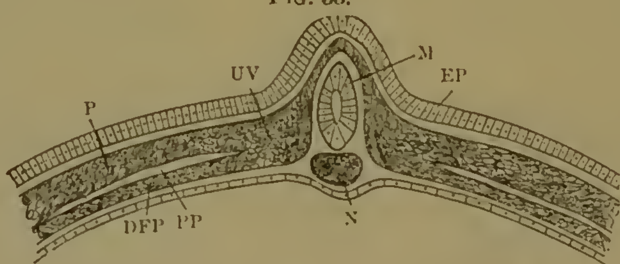
Fig. 32.



Cross-section of a Chick Embryo in the Cervical Region (after Kölliker, magnified 104 diameters): *Mc*, medullary tube, or rudiment of spinal cord; *Ect*, epiblast, which will form epidermis; *Md*, part of mesoblast which adheres to epiblast to form the splanchnopleure; *p*, the commencing pleuroperitoneal cavity; *ent*, the hypoblast; *ao*, aortic arches; *ch*, notochord; *Md'*, splanchnic layer of mesoblast.

probably all the ganglion-cells of the body. The cavity of the tube persists throughout life as the central canal of the spinal cord and as

Fig. 33.

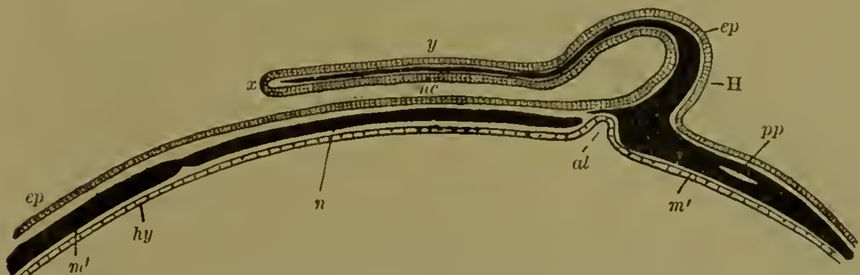


Cross-section of Chick Embryo through the Region of the Dorsal Vertebræ, after the closure of the neural canal and the extension of the mesoblast between it and those epiblastic cells, which remain in the exterior of the body and form the epidermis (the figure is very diagrammatic, and should be studied in connection with Figs. 30, 31, and 32): EP, epiblast; M, enclosed part of epiblast lining neural canal; UV, undivided portion of mesoblast; P, mesoblastic layer of body-wall; DFP, mesoblastic layer of intestinal wall; PP, commencing pleuroperitoneal cavity; N, notochord.

the fourth, third, and lateral ventricles of the brain and the passages uniting them.

Formation of the Head-fold.—Soon after the medullary folds have appeared that portion of the blastoderm which lies near their anterior end begins to rise up in the form of a fold above the general level of the rest of the blastoderm. It carries, of course, the medullary groove with it. (See Fig. 29.) After the front end of the groove is closed the brain part of the neural canal lies above this tucked-up or folded-off piece of the blastoderm, which is named the "head-fold." The diagram (Fig. 34) will aid in understanding the relations of the head-fold at this time. The figure represents a longitudinal section of the embryo soon after the appearance of the head-fold, but before the hinder end of the neural canal is closed in: *nc* is the neural canal with lining

FIG. 34.



A Longitudinal Section through an Embryo, after the head-fold has appeared and the medullary folds have met and closed in the front end of the neural canal, but are still divergent behind; a cross-section at *y* would give Fig. 33 (diagrammatic). If the medullary folds in Fig. 29 be imagined to have completely met and fused in the cranial, cervical, and anterior dorsal regions, Fig. 34 may be taken as the diagrammatic longitudinal section of the embryo represented in Fig. 29. H, head-fold; *ep*, external epiblast; *nc*, neural canal, lined by involuted epiblast; *x*, the point at which the medullary folds diverge and the neural canal is still open; *m*, mesoblast behind the embryonic region of the blastoderm; *n*, notochord; *m'*, mesoblast in front of embryonic region of the blastoderm; *hy*, hypoblast; *al*, beginning of alimentary canal (pharynx).

epiblast of its roof continuous still at its posterior opening with the external epiblast, and the lining epiblast of its floor continuous with the epiblast, which runs off to spread over the yelk. Beneath the neural canal is the notochord, *ch:* it will be noticed that it does not reach to the front of the head-fold or neural canal, but in that region is represented by a rather thick layer of mesoblast. At the tail end of the embryo, where the notochord ends, *x*, there is also a thick layer of mesoblast, that of the primitive streak. The head-fold is hollow, *al*, and its cavity lined with hypoblast and filled with yelk.

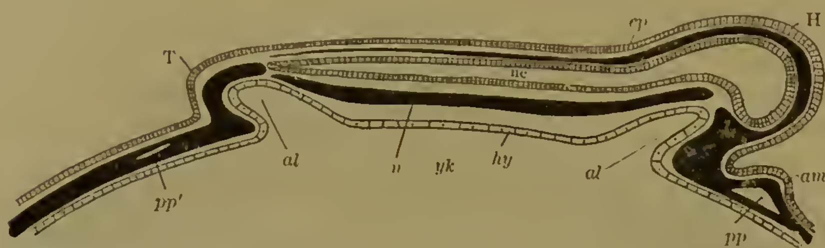
Formation of the Tail-fold.—A little later we should find the neural canal completely closed behind as well as in front, and at the tail end a fold appearing much like the head-fold, but smaller. The diagram (Fig. 35) will serve to indicate the relations at this stage.

The short tubes *al* and *al'* ultimately develop into the pharynx and rectum respectively: the buccal cavity burrows from the under side of the head-fold into the embryonic pharynx, and the cloaca similarly makes its way from the exterior to the rectum of the embryo (*c*, Fig. 43).

The Side-folds.—The embryo in the stage last figured had been tucked or folded off from the plane of the blastoderm in front and behind, but its middle region still lay nearly in the general plane of the blastoderm. A diagrammatic cross-section at this period of what will become the dorsal region of the bird is shown in Fig. 33.

Soon after the appearance of the head- and tail-folds, foldings begin on the sides of the embryo; they are continuous with the head- and

FIG. 35.



Longitudinal Section of Embryo, after the neural canal has been completely closed and the tail-fold has appeared (diagrammatic): H, head-fold; T, tail-fold; *ep*, external epiblast; *ne*, neural canal lined by involuted epiblast; *pp*, mesoblastic cleft commencing to expand and form the amnion; *pp'*, commencement of mesoblastic cleavage in the tail region; *am*, commencing amniotic fold (compare Fig. 40); *n*, notochord; *al*, front end (pharynx) of primitive alimentary canal; *al'*, posterior end (rectum) of primitive alimentary canal.

tail-folds: a cross-section of the dorsal region at this stage would be somewhat as shown in Fig. 36.

FIG. 36.

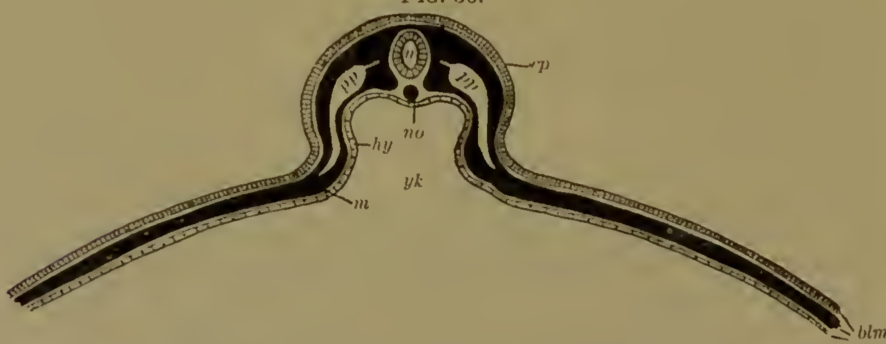


Diagram of Cross-section of Embryo soon after the Origin of the Side-folds (compare with Figs. 30 and 33): *ep*, external epiblast; *n*, neural canal (spinal cord) lined by involuted epiblast; *no*, notochord; *m*, mesoblast; *hy*, hypoblast; *blm*, peripheral non-embryonic blastoderm, with its three layers, forming the primary yelk-sac: *yk*, food-yelk; *pp*, pleuroperitoneal cavity or mesoblastic cleft, much wider when compared with the same in Fig. 33: its innermost portion does not widen, and, remaining a narrow cleft, soon becomes indistinct; traces of it may, however, be found later in the mesoblastic somites (Fig. 65).

These new foldings, known as the *side-folds* or *lateral folds*, serve, with the head- and tail-folds, to separate off a smaller upper cavity of the blastoderm from a much larger lower part (non-embryonic part) which spreads over the food-yelk. There is, however, at this stage a free communication between the two cavities, and the smaller or embryonic one contains food-yelk as well as the larger.

If, now, the under side (Fig. 35) of the head-fold were to grow backward, and the under side of the tail-fold forward, and the converging parts (Fig. 36) of the side-folds inward, there would be shut off more and more an upper smaller cavity from a lower and much larger. Ultimately, the folds would all meet at one point, and if they coalesced there would completely shut off the upper cavity. The diagrams below will illustrate this condition (Figs. 37 and 38).

FIG. 37.

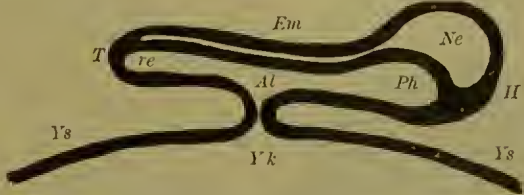


Diagram illustrating the Meeting of the Head- and Tail-folds at the Navel to close off the embryo from the yelk-sac cavity. No attempt has been made to indicate the various layers of the blastoderm. *Em*, embryonic tube; *Ys*, part of yelk-sac; *Yk*, food-yelk; *Al*, alimentary canal, nearly closed; *ph*, embryonic pharynx; *re*, embryonic rectum; the buccal and anal openings are pitted in from the exterior at a much later stage of development; H, head-fold; T, tail-fold; *Nc*, neural canal.

FIG. 38.

Diagram illustrating the Meeting of the Side-folds, to close off the embryo from the yelk-sac; *Ys*, part of yelk-sac; *Yk*, food-yelk; *Al*, alimentary canal; *Em*, embryo; *Nc*, neural tube.

In essentials the folds do grow in this way and meet at the navel, there again to diverge and spread over the yelk. The smaller cavity thus loses direct communication with the larger cavity surrounded by the non-embryonic part of the blastoderm: its lining hypoblast gives rise to the epithelium of the alimentary canal, to the gland-cells of the liver and pancreas, and to the epithelium of the lungs and air-passages.

The Cleavage of the Mesoblast and the Separation of the Body-wall and Alimentary Tube.—Such a cross-section as is represented in Fig. 38 would, supposing the alimentary tube to have become quite closed below and the yelk-sac got rid of, fairly well represent diagrammatically a cross-section of the neck of the adult bird. In that region of the body we could pass a needle from the epidermis outside to the epithelium of the gullet inside without traversing any body-cavity. But in the thoracic and abdominal regions this is not possible: in them, to get from the skin to the alimentary canal the *body-cavity* (*pleuroperitoneal cavity* or *cœlome*) must be traversed. A diagrammatic cross-section of the adult bird in the abdominal region would not be represented fairly by Fig. 38, but rather by some such diagram as Fig. 39.

We have then to seek the origin of this great body-cavity. In the bird the thoracic and abdominal cavities remain continuous throughout life: in the mammalian embryo also the cœlome is undivided at first, though afterward subdivided by the diaphragm. The development of the cœlome is closely associated with that of the amnion, which is at first a part of it.

Fig. 39.

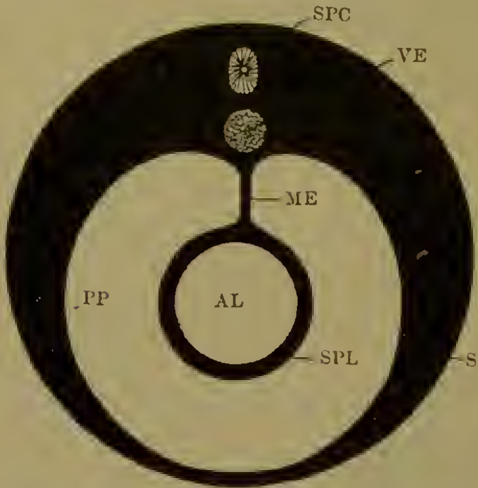


Diagram of Cross-section of One of the Higher Vertebrates in the Abdominal Region: SPC, spinal cord; VE, centrum of a vertebra; ME, mesentery; AL, intestinal cavity; SPL, wall of intestine; SO, body-wall; PP, body-cavity (cœlome).

The mesoblast of the embryonic region of the blastoderm we have seen (*p*, Figs. 27 and 30) to very early separate into a central axial rod, the *notochord*, and two *peripheral* plates. These plates are at first completely continuous from their inner to their outer surface, but even before the side-folds rise up, a cleft appears in the mesoblast, separating each plate into an inner and outer layer of cells. This cleft (Figs. 34, 35, *pp*) lies quite beyond the head- and tail-folds, but (Figs. 32, 33, 36, *pp*) it reaches in the side-folds to near the notochord and neural tube. The outer layer tends to adhere to the epiblast and to follow it in its foldings; the inner, to the hypoblast and follow it. The innermost, or most medial portion of the mesoblastic cleft (see Fig. 36), remains narrow and soon disappears; but more peripherally the cleft widens to form the body-cavity (*pp*, Fig. 36) and the amnion.

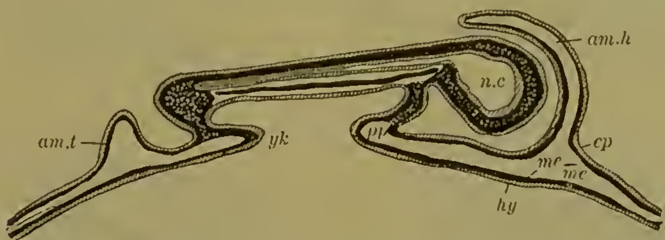
The outer layer of the divided mesoblast, which adheres to the epiblast, forms with it the *somatopleure*, from which the lateral and ventral walls of the trunk are developed (Fig. 36). The inner layer of mesoblast joins the hypoblast and forms with it the *splanchnopleure*, which in the embryonal region of the blastoderm gives rise to the coats of the greater part of the alimentary canal. Its non-embryonic portion forms the secondary or true yelk-sac (Fig. 42).

The Development of the Amnion.—The first trace of the amnion is (*am*, Fig. 35) a divergence of the somatopleure from the splanchnopleure a little way in front of the head-fold of the embryo. As seen in Fig. 28, this upgrowth is concentric with the head-fold at first.

At a somewhat later stage (Fig. 40) the amniotic upgrowth (*am.h*) in the head-region increases rapidly, and arches over the head of the embryo, while a similar upgrowth of the somatopleure (*am.t*) commences behind the tail of the chick.

The amniotic tail-fold grows forward over the back of the embryo; the amniotic head-fold grows backward; finally, they meet and fuse

Fig. 40.



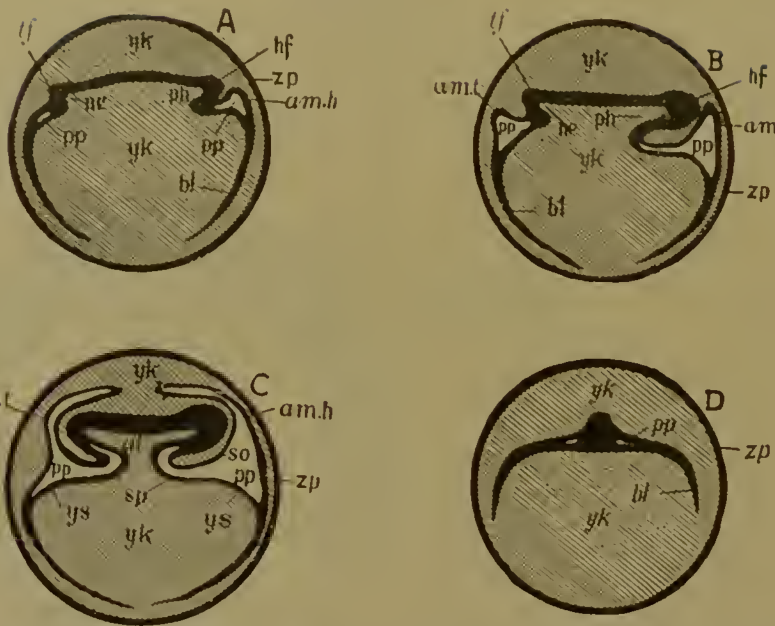
A Diagram of a Longitudinal Section of the Chick Embryo, to illustrate the formation of the amnion: *n.c*, brain dilatation of the anterior end of the neural tube, lined by its involuted epiblast; *am.h*, head-fold of amnion; *am.t*, tail-fold of amnion; *pp*, pleuroperitoneal cavity; *ep*, external epiblast; *me*, outer layer of mesoblast, which adheres to epiblast to form the somatopleure; *hy*, hypoblast; *me'*, inner layer of mesoblast, which adheres to hypoblast to form with it the splanchnopleure; *yk*, food-yelk.

(see A, B, C, Fig. 41; A, Fig. 42; also Fig. 43). Meanwhile, amniotic side-folds have appeared (see D, E, F, G, H, Fig. 41, and B, Fig. 42), continuous in front and behind with the amniotic head- and tail-folds; these gradually grow up over the back of the embryo, and, meeting the other folds, fuse with them and enclose the tail, head, and back of the chick in a double-walled sac of somatopleure containing a cavity continuous with the pleuroperitoneal cavity and with the cleft in the mesoblast, which is gradually spreading all over the non-embryonic region of the blastoderm. The diagrams given in Figs. 41, 42, 43 will make the stages of development clearer than many pages of mere verbal description. It must be borne in mind that the figures are the merest diagrams, and that every other contemporary detail in the embryonic development has been sacrificed in order that the various stages in the growth of the amnion may be made more obvious.

In A, Fig. 41, the head- and tail-folds of the embryo are indicated (*hf*, *tf*), and the commencing enclosure of the front end (*ph*) and hind end (*ne*) of the alimentary canal; also, the pleuroperitoneal clefts (*pp*) in the mesoblast in front of the head-fold and beyond the tail-fold. In the head region the somatopleure is seen to have commenced its upward growth to form the first indication of the head-fold of the amnion (*am.h*).

In B, which also represents a longitudinal section, the amniotic head-fold is seen to have increased in size, and the amniotic tail-fold to have commenced (*am.t*). Meanwhile, the non-embryonic region of the blastoderm (*bl*) has spread farther round the food-yelk. In all the diagrams in Fig. 41 the distance between the embryo and the zona pellu-

Fig. 41.



Eight Diagrams to Illustrate the Origin of the Amnion, and its relationship to the primary body-cavity (pleuroperitoneal cavity, cœlome) in the bird embryo. The size of the embryo is much exaggerated in the figures, as also the distance between it and the zona pellucida, and between the latter and the non-embryonic region of the blastoderm. A more detailed account of what the diagrams are intended to make clear will be found in the text.

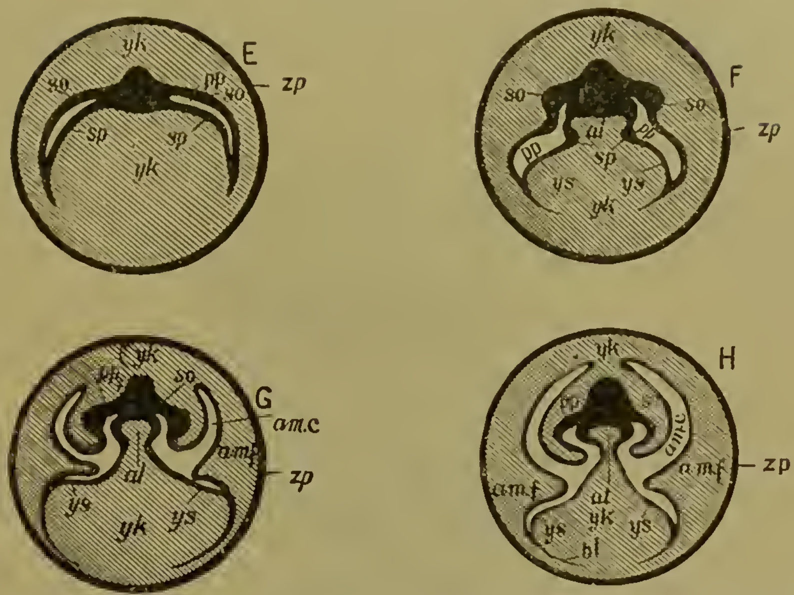
yk, food-yelk; *zp*, zona pellucida; *hf*, head-fold of embryo; *tf*, tail-fold of embryo; *am.h*, head-fold of amnion; *am.t*, tail fold of amnion; *pp*, pleuroperitoneal cavity; *so*, somatopleure;

cida (*zp*) is much exaggerated, and also the space between the non-embryonic blastoderm and the zona.

In C, Fig. 41, the amniotic head- and tail-folds are shown as having greatly increased in size, and as having nearly met over the dorsal region of the embryo, while the cleft in the mesoblast is seen to have extended through the non-embryonic part of the blastoderm for some distance, giving rise to a considerable cavity (*pp*), which is now continuous with the future pleuroperitoneal space on the one hand, and with the primary amniotic cavity on the other.

The remaining diagrams in Fig. 41 represent cross-sections of the embryo and illustrate the development of the side-folds of the amnion. In D is shown the commencement of the pleuroperitoneal cleft. In E the mesoblastic cleavage is represented in a more advanced stage, when it has spread some distance over the non-embryonic region of the blastoderm. In F are indicated the thickening of somatopleure and splanchnopleure in the embryonic region, and the folding off of the embryo from the general plane of the blastoderm. In G the side-folds of the amnion are represented as well advanced, and the embryo as still further differentiated from the non-embryonic area. In H the side-folds of the amnion are seen to have almost met over the back of

FIG. 41 (*bis*).

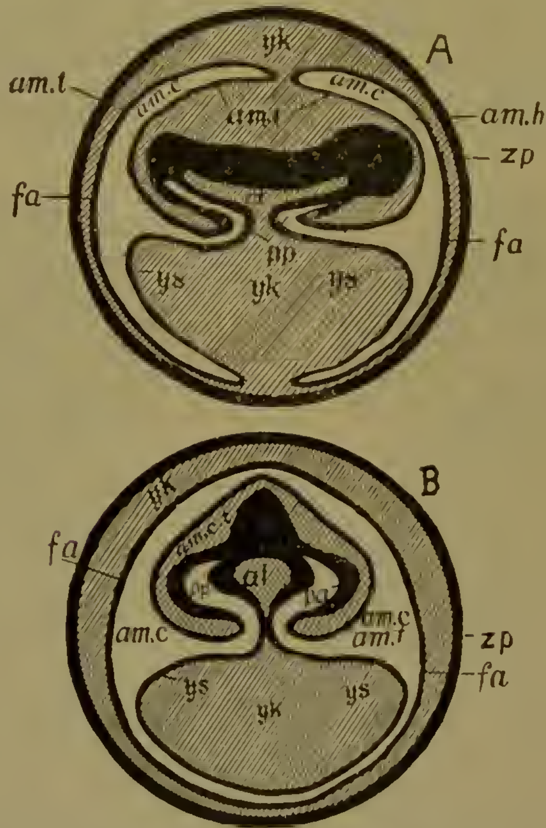


sp, splanchnopleure; *ys*, yelk-sac; *ph*, commencement of formation of pharynx; *re*, beginning of rectum; *al*, alimentary canal after the splanchopleures have curved in so as to partially enclose other of its regions, in addition to pharynx and rectum. The diagrams indicate how the false amnion (*am.f*), consisting of non-embryonic somatopleure, is separated from the true amnion above the embryo, and from the non-embryonic splanchnopleure below the embryo; this non-embryonic splanchnopleure forming the *yelk-sac*, the cavity of which remains for a time continuous with the cavity of the primitive alimentary canal by a narrow hollow tube, the *umbilical duct*.

the embryo, while the cleavage of the mesoblast has extended a considerable distance along the non-embryonic mesoblast, tending to split off the non-embryonic somatopleure (*am.f*), as the *false amnion*, from the non-embryonic splanchnopleure (*ys*, H, Fig. 41), which forms the true yelk-sac. In all the diagrams in Fig. 41 the size of the embryo in relation to the whole egg and to the yelk-sac is greatly exaggerated.

In Fig. 42 there are given diagrams illustrating later stages in the development of the amnion. A is a longitudinal section at a period when the head and tail amniotic folds have nearly met above the back of the embryo, and when the cleavage of the mesoblast has nearly spread to the lower margin of the non-embryonic blastoderm. The primary amniotic cavity (*am.c*) is seen to be continuous with the pleuroperitoneal cavity (*pp*), and the false amnion (*fa*) to have very nearly separated from the true amnion (*am.t*) above the embryo, and from the yelk-sac (*ys*) below. B, Fig. 42, represents a transverse section of the embryo when the amniotic folds have met and fused over the embryo. The inner layers (*am.t*) of the primary amnion have joined to form the true *amnion* and enclose the true amniotic cavity (*am.c.t*). The outer layers (*fa*) of the primary amnion have met and united above the embryo, and a continuation of the mesoblastic cleft over the whole non-embryonic blastoderm has entirely separated them and their extensions over the food-yelk from the embryo and from the yelk-sac (*ys*), to form

Fig. 42.



A, Longitudinal Section of Bird Embryo (diagrammatic) just before the head and tail amniotic folds have met over the back of the chick: the yelk-sac (*ys*) is almost completely separated from the false amnion, *fa*, by extension of the primary amniotic cavity, *am.c*, through the non-embryonic blastoderm; *zp*, zona pellucida; *am.h*, head-fold of amnion; *fa*, false amnion; *am.t*, true amnion, nearly enclosing the true amniotic cavity; *pp*, pleuroperitoneal cavity, continuous with the primary amniotic cavity; *yk*, yelk; *ys*, yelk-sac.

B, Diagram of Cross-section of Embryo after the side-folds of the amnion have met over its back (compare with II, Fig. 41). The mesoblastic cleft has entirely separated the yelk-sac from the false amnion; the communication between the primitive alimentary canal (*al*) and the cavity of the yelk-sac is nearly closed, the two only communicating by a narrow stalk; *zp*, zona pellucida; *fa*, false amnion; *am.t*, true amnion; *am.c.t*, cavity of true amnion; *am.c*, cavity of primitive amnion, continuous with pleuroperitoneal cavity, *pp*; *pa*, part of somatopleure which will form outer walls of body-cavity; *al*, alimentary canal, nearly closed below, and bounded on its sides by those portions of the splanchnopleure which will ultimately form the walls of most of the alimentary canal; *ys*, peripheral splanchnopleure, forming the yelk-sac; *yk*, chief mass of food-yelk: this is actually much larger in proportion to the embryo than represented in the diagram.

the separate layer known as the *false amnion* (*fa*). The splanchnopleures have nearly met below the intestine (*al*), so as to shut off the cavity of the yelk-sac from direct communication with the cavity of the alimentary canal. Those portions of the somatopleures (*pa*) which will ultimately form the body-walls of the embryo have not yet converged as much as the splanchnopleures, so that a space is left between the narrow stalk of the yelk-sac and the point where the somatopleure is reflected on each side to form the true amnion; through this space the pleuro-peritoneal cavity (*pp*) is in free communication with the cavity (*am.c*) of the primitive amnion.

In Fig. 43 is represented a longitudinal section of a bird embryo after the head and tail amniotic folds have met and after the false amnion

FIG. 43.

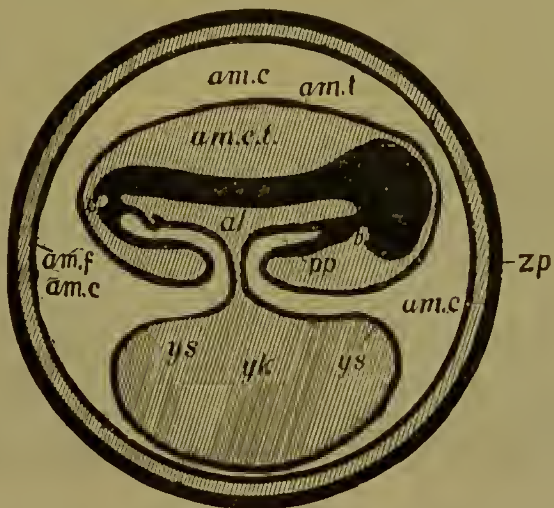


Diagram of a Longitudinal Section of an Embryo Chick, after the false amnion has been entirely separated from the true amnion and from the yelk-sac (compare with A, Fig. 42): *zp*, zona pellucida; *am f*, false amnion: *am.t*, true amnion; *am.c*, primitive amniotic cavity, continuous with the pleuroperitoneal cavity, *pp*; *al*, alimentary canal; *b*, commencement of buccal cavity as an involution from the surface of the embryo beneath its head-fold; *c*, commencement of cloaca as an involution from the exterior of the tail-fold; *am.c.t*, true amniotic cavity; *yk*, food-yelk; *ys*, yelk-sac, continuous with the splanchnopleure, which will ultimately form the walls of most of the alimentary canal.

has been completely separated from the yelk-sac (compare with B, Fig. 42). The diagram also indicates the commencing epiblastic involution, *b*, which will ultimately open into the anterior end of the primitive alimentary canal and form the buccal cavity (*stomadæum*); the epiblastic ingrowth, *c*, which will ultimately open into the hinder end of the alimentary canal and form most of the cloaca (*proctodæum*); and the commencement of the allantois as a tubular outgrowth from the ventral side of the posterior portion of the alimentary tube. The allantoic tube subsequently grows forward in the pleuroperitoneal cavity, and, passing through the space between the stalk of the yelk-sac and the point where the tail-fold of the true amnion turns back, extends into the primitive amniotic cavity, *am.c*, to form, in mammals, the fœtal portion of the placenta.

The Meaning of the Formation of the Blastodermic Vesicle of the

Higher Mammals.—We may now return to the consideration of the developing oosperm of the rabbit. When last studied it consisted of an embryonic area (Fig. 17, *hy*) and of a non-embryonic set of cells, *ep*, which surrounded the cavity of the blastodermic vesicle, and had also, as the *cover-cells*, grown over the original exposed portion (p. 102) of the true embryonic portion of the blastoderm. These cover-cells, it was stated, took no further distinctive part in the formation of the embryo; they were either absorbed or they fused with the true embryonic epiblast. In Figs. 44 and 45 are depicted embryonic rabbits at this stage of development: the embryos were taken from the uterus seven days after coition. Fig. 44 is a view of the developing

Fig. 44.

Fig. 45.

Fig. 44.—Rabbit's Embryo, taken from the uterus seven days after fertilization, seen from above (the blastodermic vesicle was 3.47 mm. in length): *mo*, remnant of zona pellucida: *ge*, limit of extension of hypoblast beneath blastodermic vesicle; *ag*, embryonic area or germinal area.
Fig. 45.—The Same Embryo as in Fig. 44, viewed from one side (the zona pellucida has been removed): *ag*, embryonic area; *ge*, peripheral limit of hypoblast (from Kölliker). Both figures magnified about ten diameters.

oosperm from above; it shows the germinal area, *ag* (=area pellucida of chick), and the limit to which the hypoblast, *ge*, has spread beneath the blastodermic vesicle; also the zona pellucida, *mo*. Fig. 45 is a side view of the same embryo, the zona pellucida being omitted; *ag* is again the germinal area, and *ge* points to the limit of the extension of the hypoblast beneath the non-embryonic epiblast at this epoch.

In the embryonic or germinal area a primitive streak and groove next make their appearance, much as in the area pellucida of the developing bird embryo (Fig. 24). As seen in the rabbit, these structures are represented in Figs. 46 and 47.[1]

In order to understand the mode of segmentation of the ovum of higher mammals and the meaning of the blastodermic vesicle, we must bear in mind that the earliest and ancestral mammals were oviparous—that they

[1] The primitive streak and groove of embryonic reptiles, birds, and mammals are remnants of an ancestral structure, the *blastopore*. (See Balfour: *Comp. Embryol.*, vol. ii. pp. 187 and 238.)

laid eggs containing much food-yelk and much like the eggs of reptiles and birds. The lowest existing Mammalia (echidna, ornithorhynchus)

Fig. 46.

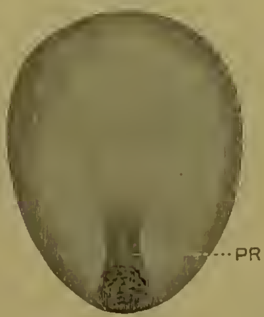


Fig. 47.

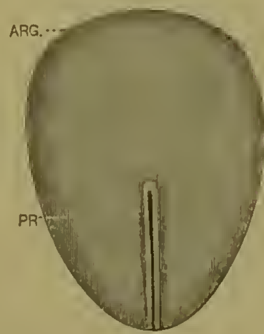
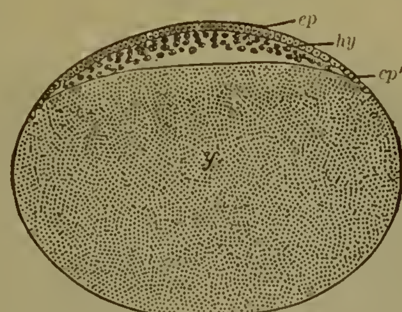


Fig. 46.—Germinal or Embryonic Area of Rabbit Embryo of seven days, seen from above (magnified about 30 diameters): *pr*, primitive streak.

Fig. 47.—Embryonic Area of Rabbit Embryo eight days after coition: *pr*, primitive streak, with primitive groove formed along it.

still lay such eggs, and their embryos are developed outside of the body of the mother, as the embryo chick is. In the marsupials (kangaroos, opossums) the embryo undergoes only a very small part of its development within the uterus; it is born inactive, unable even to suck (the milk being pumped into its gullet by a special muscle covering the maternal mammary gland), and in a condition answering to an early aborted human fœtus. In all the higher mammals (eutheria) the food-yelk is reduced to a minimum, and the embryo is retained and nourished within the womb of its mother until its development is far advanced; but even in these the earliest stages of embryonic development indicate descent from ancestors which laid meroblastic eggs.

Fig. 48.



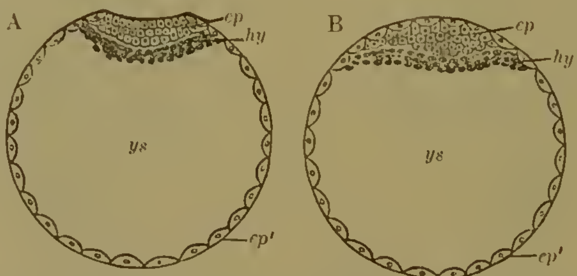
(From Haddon): Diagrammatic Transverse Section through the Blastoderm and Yelk of the Oosperm of a Hypothetical Primitive Mammal: *ep*, epiblast of future embryo; *ep'*, non-embryonic epiblast, which is surrounding the yelk; *hy*, primitive hypoblast; *y*, food-yelk.

The facts at present known seem to indicate that the primitive mammalian ovum (and probably still that of echidna and ornithorhynchus) had some such structure as is indicated in Fig. 48. To quote from Haddon[1] (with whom Minot in the main agrees): "The [segmenting] oosperm of a primitive mammal, ... in which the [food-] yelk was still present, is represented in Fig. 48. The blastoderm, which rests upon the [food-] yelk, consists of an epiblastic layer and a mass of lower

[1] *Introduction to the Study of Embryology*, p. 47.

cells; the [food-] yelk is being surrounded by the non-embryonic epiblast." "A [segmenting] oosperm in which the [food-] yelk is supposed to have been lost is shown in Fig. 49, A." Owing to the absence of food-yelk, the non-embryonic area of the epiblast, having nothing to

FIG 49.



Diagrammatic Transverse Section through a Hypothetical Mammalian Oosperm, after the primary layers of the blastoderm had been formed by segmentation of the fertilized egg (the food-yelk of the original mammalian ovum is supposed to have been lost): A, earlier, and B, later stage of development; *ep*, embryonic epiblast; *ep'*, non-embryonic epiblast; *ys*, cavity of blastodermic vesicle enclosed by non-embryonic epiblast (after Haddon).

grow around, "has precociously completed the blastodermic vesicle, and the [embryonic portion of the] blastoderm has sunk into the cavity of the empty [blastodermic vesicle]." The non-embryonic epiblast then (Fig. 49, B) grows over the embryonic area as the cover-cells (p. 104). In this way would arise something very like what we actually find to

FIG. 50.

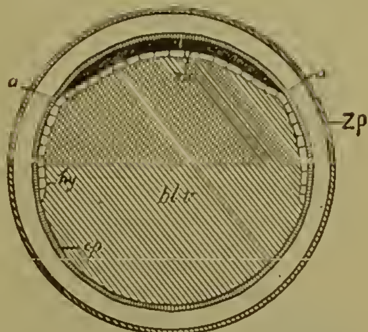
Oosperm of a Rabbit, seven days after coition, seen from above (the zona pellucida has been removed; the oosperm was 4.4 mm. in length): *ag*, embryonal area; the rest is non-embryonic blastoderm (magnified 10 diameters) (from Kölliker).

occur in the early stages of the development of the rabbit (Figs. 16 and 17) and some other higher mammals.

If the theory of Haddon and Minot be accepted, the blastodermic vesicle must be regarded as a mere survival from a time when a food-yelk was present in all mammalian eggs. In the now-existing higher mammals it contains no yelk, but becomes filled and distended by an albuminous liquid absorbed from the uterine mucous membrane.

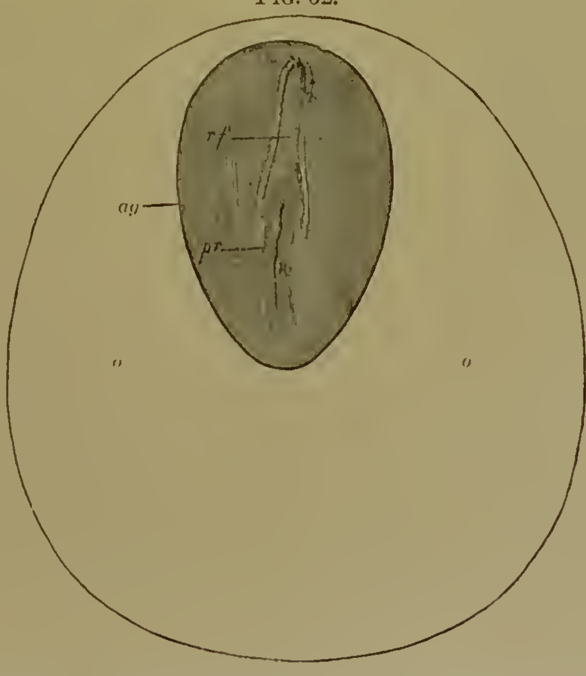
The Development of the Fœtal Membranes and Appendages of the Mammal,[1] while in essentials similar to that of the bird, presents certain differences which we must now consider. These are, in part, due to the relatively small size and trivial importance of the mammalian yelk-sac, and to its very early completion and subsequent rapid shrinkage. From Fig. 50 may be gained some idea as to the relative extent of the embryonic and non-embryonic areas of the rabbit's oosperm at a stage shortly after the formation of the mesoblast in the embryonic region, and when the hypoblast has spread beyond that region and halfway around the embryonic vesicle.

Fig. 51.



Longitudinal Section of Mammalian Embryo when the hypoblast is about halfway round the blastodermic vesicle: *a*, *a*, anterior and posterior ends of embryonic area; *zp*, zona pellucida; *ep*, epiblast; *hy*, hypoblast, *me*, mesoblast; *bl.v*, cavity of blastodermic vesicle.

Fig. 52.



Embryonic Area and Part of Non-embryonic Area of a Rabbit Embryo at the seventh day (from Kölliker; magnified 28 diameters): *ag*, embryonic area; *o*, neighboring part (*vascular area*) of non-embryonic blastoderm; *pr*, primitive streak; *rf*, medullary groove.

In Fig. 51 is a diagram representing a longitudinal section of an

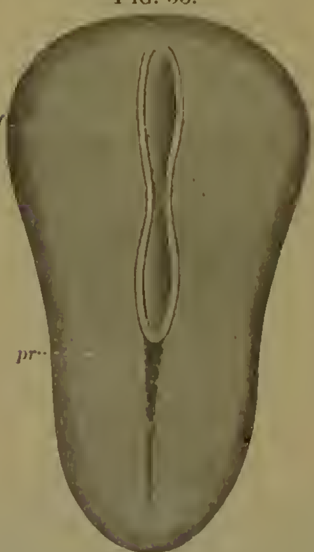
[1] In what follows the word "mammal" will be used as meaning only the *Eutheria*.

embryo in this stage. The extent of the embryonic area and of the mesoblast is, however, exaggerated, and a much wider space than actually exists is indicated between the oosperm and the zona pellucida.

As development proceeds the hypoblast spreads, until it finally lines the whole non-embryonic epiblast; the mesoblast, spreading more slowly, ultimately does the same.

The formation of the medullary folds, groove, and canal (Figs. 52, 53), and of the notochord, and head-, tail-, and side-folds, occurs in the mammal in essentially the same manner as in the chick (p. 110), and need not be again described. The same may be said of the cleavage of the mesoblast (p. 116).

Fig. 53.



Embryonic Area of Rabbit Embryo, aged eight days and four hours (from Kölliker; magnified 20 diams.): *rf*, medullary groove; *pr*, primitive streak.

The Mammalian Amnion presents some peculiarities in its development which are illustrated in Fig. 54 and several succeeding diagrams. These are based on the observations of Van Beneden and Julin made on the rabbit:[1] probably the human amnion develops in a similar manner, but its earliest stages have not been observed, and His has concluded that its origin is not like that in most mammals. The conclusion of His[2] will probably be ultimately found to be erroneous.

At a time shortly before the mesoblastic cleavage or the amniotic folds have commenced, the head end of the embryo sags down, pushing before it the subjacent non-embryonic blastoderm, which here consists of the three typical layers. The blastodermic bag which thus comes to partially envelop the head is known as the *pro-amnion*, and it still persists for some time after the formation of the amniotic folds has commenced (*pr.a*, Fig. 54). It is subsequently obliterated.

In the bird the first mesoblastic cleft and the first amniotic fold occur at the head end of the embryo. In the mammal the reverse is the case: when the amniotic tail-fold (Fig. 54, *a.t.f*) is well developed and the pleuroperitoneal cavity and the primitive amniotic cavity (*amc*) are conspicuous in the tail region, there is a mere trace of a pleuroperitoneal cavity in front of the head, and a very rudimentary head-fold of the amnion (*ahf*).

Moreover, in the chick (Fig. 40) both layers of the amniotic folds contain mesoblast and epiblast; in the mammal only the inner layer, which is to form the true amnion, possesses any mesoblast.

At a somewhat later stage (Fig. 55) the true amnion is completed

[1] *Arch. de Biologie*, t. v. p. 369.

[2] *Anatomie Menschlicher Embryonen.*

over the back of the embryo, and the mesoblastic cleft (*amc.p*) has extended back through that portion of the blastoderm which originally formed the pro-amnion. The false amnion is also seen to have separated to a considerable extent from the blastodermic vesicle, which has become reduced in size and covered more than halfway round by mesoblast. Still later (Fig. 56), the false amnion (*fa*) is seen to have

FIG. 54.

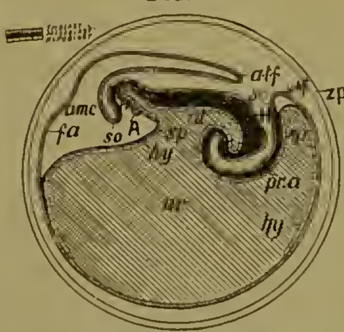


FIG. 55.

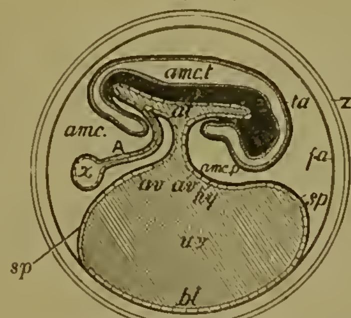


FIG. 54.—Diagram illustrating Formation of the Fœtal Appendages in a Mammal: H, head of embryo; *pr.a*, pro-amnion; *pp*, tail portion of pleuroperitoneal cavity; *amc*, tail portion of primitive amniotic cavity; *a.t.f*, tail-fold of amnion; *ahf*, head-fold of amnion; *so*, somatopleure; *sp*, splanchnopleure; *fa*, false amnion, consisting only of epiblast; *hy*, hypoblast; *al*, alimentary canal, still communicating freely below with the cavity, *ur*, of the blastodermic vesicle, which will ultimately become the cavity of the yelk-sac, or, as it is named in mammals, the *umbilical vesicle*; *zp*, zona pellucida; A, allantois.

FIG. 55.—Diagram of a Fœtal Mammal, at a more advanced stage than represented in Fig. 54. The amniotic folds have united over the back of the embryo; the false amnion (*fa*) has been separated except at the lower side of the blastodermic vesicle (*bl*): *ta*, true amnion; *amc.t*, cavity of true amnion; *amc*, *amc.p*, cavity of primitive amnion continuous with pleuroperitoneal cavity of body of embryo; *al*, alimentary canal; *ur*, umbilical vesicle or yelk-sac, not yet quite separated from the false amnion below, or entirely surrounded by mesoblast; *sp*, splanchnopleure of umbilical vesicle, consisting of hypoblast and mesoblast, and continuous above with the splanchnopleure of the alimentary canal; *hy*, hypoblast; *av*, thickened region of mesoblast of umbilical vesicle, in which extra-embryonic blood-vessels subsequently arise and form the *area vasculosa*; A, allantois; *x*, the vesicular dilatation at its termination.

become entirely free from the embryo and the blastodermic vesicle, and to have come into contact and fused with the zona pellucida. It is henceforth known as the *subzonal membrane*, and, as the diagrams show, is at all parts composed of epiblast only.

The Amniotic Fluid, enclosed within the true amnion, varies much in amount in different stages of pregnancy. Its average quantity at the time of parturition of the human fœtus is about 680 cubic centimeters. It is probably a serous liquid transuded from the blood-vessels of the mother, and not, as has been maintained, an excretion from the embryo.[1]

The amniotic liquid protects the embryo from mechanical injury by sudden blows, assists in maintaining a uniform temperature around it, and gives opportunity to the fœtus to make intra-uterine movements.

The Umbilical Vesicle, as the mammalian yelk-sac is named, is formed,

[1] Minot: *Reference Handbook of Medical Sciences*, vol. i. p. 141.

as in the bird (see Fig. 41), by the infolding of the embryonic splanchnopleure to enclose the alimentary canal, and then its divergence to spread over the non-embryonic region; and by the separation of the false amnion from the rest of the non-embryonic blastoderm. At first (*uv*, Fig. 54) it communicates by a wide opening with the primitive alimentary tube, and is but partially surrounded by hypoblast, and only to a small extent by mesoblast. Somewhat later (Fig. 55) its cavity is found to have diminished, its communication with the alimentary canal to have narrowed so as to form a short stalk, the hypoblast to have grown all around it, and the mesoblast more than halfway. The mesoblast of the developing umbilical vesicle just beyond its stalk now becomes thicker than elsewhere, and numerous blood-vessels arise in it and establish communications along the stalk with arteries and veins which have by this time appeared in the embryo. This highly vascular region of the umbilical vesicle is known as the *area vasculosa.* This area never attains any great importance in the mammal, and soon loses its blood-vessels: in birds it ultimately extends over nearly the whole of the large yelk-sac, and serves to transmit food from the white and yelk to the embryo.

As development proceeds the false amnion completely separates from the umbilical vesicle and the mesoblastic layer completely surrounds the latter (Fig. 56). The vesicle rapidly diminishes in size, and its stalk,

FIG. 56.

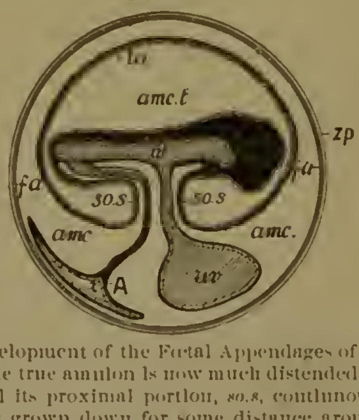


Diagram to Illustrate the Development of the Fœtal Appendages of a Mammal, at a later stage than shown in Fig. 55. The true amnion is now much distended by the accumulation within it of amniotic liquid, and its proximal portion, *so.s*, continuous with the infolding body-walls of the embryo, has grown down for some distance around the umbilical duct and allantois, forming a sort of sheath (*so.s*) for them: *fa*, false amnion, or subzonal membrane, now attached to the inner surface of the zona pellucida, *zp*, and having no attachment to any part of the embryo or umbilical vesicle: *ta*, true amnion: *amc.t*, cavity of true amnion: *amc*, cavity of primitive amnion, continuous with pleuroperitoneal cavity of embryo; *al*, alimentary canal; *uv*, umbilical vesicle, connected by the long narrow umbilical duct with the alimentary canal; A, allantois, commencing to spread out beneath the subzonal membrane; *x*, cavity of allantoic vesicle, lined by hypoblast. The stalk of the allantois is seen to be still hollow above and to communicate with the alimentary canal.

now known as the *umbilical duct*, becomes longer and narrower, though it still remains pervious for some time, affording a direct channel of communication, lined by hypoblast and covered by mesoblast, between the alimentary canal (now nearly closed in below) and the cavity of the umbilical vesicle. At a still later stage (Fig. 57) the umbilical duct is found to have become solid, though still containing a core of hypoblast cells; and the vesicle to have dwindled to a mere remnant: the alimentary tube is entirely closed in by the convergence and fusion of the splanchnopleure folds at the upper end of the umbilical duct. The portion of the intestinal tube to which the umbilical duct is attached becomes ultimately the ileum.

In the human embryo the period during which the umbilical vesicle increases in size ends at about the sixth week: then its rapid diminution commences. Traces of it may, however, be found at birth.

The Allantois is an extremely important fœtal appendage, which co-operates with the subzonal membrane and the uterine mucous membrane to form the placenta. It is from the morphological standpoint a special development of the urinary bladder existing in all vertebrates higher than amphibia during fœtal life, and used either to aërate the blood of the embryo (reptiles, birds) or, in addition (mammals), to provide it with nourishment and carry off other wastes as well as carbon dioxide. Though well developed in the chick, giving rise to a highly vascular membrane which lies close to the shell and serves to aërate the blood of the embryo, we did not describe it in the bird, as the ultimate differences between the avian and the mammalian allantois are so great that the history of the development of one does not aid much in understanding that of the other.

The allantois commences (A, Fig. 54) as a tubular outgrowth from the hinder end of the primitive alimentary canal. This outgrowth is lined by hypoblast and covered by mesoblast. As the splanchnopleure folds-in at the tail region of the embryo, closing the hinder part of the body-cavity, the allantois (Fig. 55) grows rapidly forward as a narrow tube to near the stalk of the umbilical vesicle: there it turns away from the embryo and grows into a long hollow stalk, which dilates at its end into a vesicle, *x*. At a somewhat later stage (Fig. 56) most of the stalk of the allantois is found to have become solid, though microscopic examination shows some hypoblastic cells (not indicated in the diagram) all along it. Its terminal vesicle, *x*, is found to have reached the inner side of the subzonal membrane, and to have commenced to flatten out against it. Still later (Fig. 57), the allantoic stalk is longer and relatively narrower, the cavity of the vesicle has disappeared, and the mesoblast of the allantois has spread on every side all around the embryo as a lining to the subzonal membrane, to which it adheres intimately.

The proximal end of the allantois does not become solid: it dilates (*o*, Fig. 57), and, losing later its connection with the alimentary canal and making a separate opening on the exterior, it receives the ureters (p. 194) and becomes the urinary bladder. When the somatopleure folds of the embryo meet at the navel and close-in the body-cavity, a part of the allantoic stalk, reaching from the bladder to the navel, is enclosed in

FIG. 57.

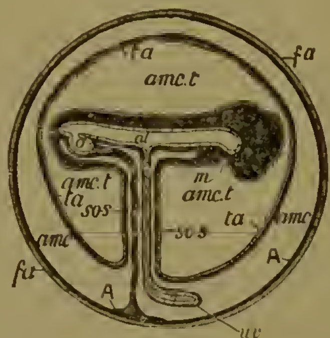


Diagram of a Human Embryo when the allantois has spread all over the interior of the subzonal membrane: *fa*, subzonal membrane; A. allantois; *o*, proximal dilatation of the allantois which will ultimately form the urinary bladder; *ta*, true amnion, *amc.t*, cavity of true amnion: *so.s*, downward extension of true amnion, forming the somatopleuric stalk of the umbilical cord; *amc*, primitive amniotic cavity, still continuous through the umbilical cord with the pleuroperitoneal cavity; *m*, commencing involution of the buccal cavity: a similar involution at the tail end indicates the beginning of the anal opening; *uv*, remnant of umbilical vesicle. The zona pellucida has either been absorbed or has so fused with the subzonal membrane as to be indistinguishable.

that cavity: it forms the *urachus*, or, in the adult, the *ligamentum vesicæ medium*. The details of allantoic development differ considerably in various mammals: the foregoing description applies to the human embryo.

Blood-vessels very soon develop in the mesoblast of the allantois, and blood is brought to them by a pair of *umbilical* or *allantoic arteries*, which are given off from the terminal bifurcation of the aorta (p. 175). This blood is returned to the embryo at first by a pair of large umbilical veins, one of which, however, soon dwindles away.

The Umbilical Cord is a complex structure attached to the ventral surface of the embryo: as shown in an early stage of its development in Fig. 57, it is short and wide, and consists of (1), externally, a sheath of somatopleure formed by a downgrowth of the amnion, and known as the somatic stalk; (2) the narrow remnant of the umbilical duct continuous with the splanchnopleure of the embryo, and known as the splanchnopleuric stalk; and (3) the extra-embryonic portion of the stalk of the allantois. A cross-section of the cord in this stage is diagrammatically represented in Fig. 58.

As development progresses the umbilical cord becomes relatively longer and narrower (Fig. 60). The somatopleures, folding in more and more until they meet at the navel and close-in the cœlome, carry the somatopleuric stalk with them until it ultimately comes into contact with the stalks of the umbilical vesicle and yelk-sac, and all fuse together to make one solid cord traversed by the allantoic blood-vessels, of which the arteries wind in a spiral manner round the veins. The mesoblast of the somatic stalk becomes converted into *jelly-like connective tissue* (*jelly of Wharton*), and binds all the rest together. A cross-section of the cord in this stage is represented in Fig. 59.

From the structure and attachments of the umbilical cord it will be obvious that when it is severed at the navel at birth, the true amnion

Fig. 58.

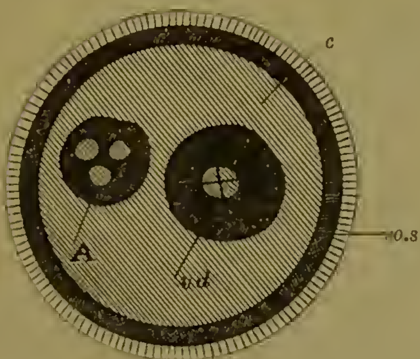


Fig. 59.

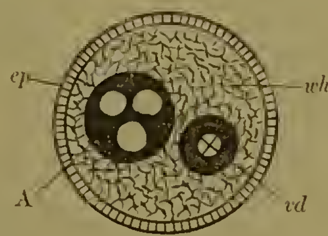


Fig. 58.—Diagram of Cross-section of Umbilical Cord at an early stage of its development: *so.s*, somatopleuric stalk derived from amnion, and consisting externally of epiblast and internally of mesoblast; *vd*, umbilical duct or splanchnopleuric stalk, composed of mesoblast with a hypoblastic core; A, stalk of allantois, mesoblastic, and showing the two allantoic arteries and the allantoic vein in cross-section; *c*, cavity of umbilical cord.

Fig. 59.—Diagram of Cross-section of Umbilical Cord after all its elements have come together and the jelly of Wharton (*wh*) has been developed from the amniotic mesoblast; *ep*, epiblast of amniotic stalk; A, allantoic stalk; *vd*, umbilical duct.

(previously ruptured by the embryo during parturition) will remain attached to it, as also the allantois and whatever (placental) structures may have developed in connection with that organ, and that the remnant of the umbilical vesicle and ducts will be included in it. All these parts are, in fact, normally expelled together in one mass, the *after-birth.*

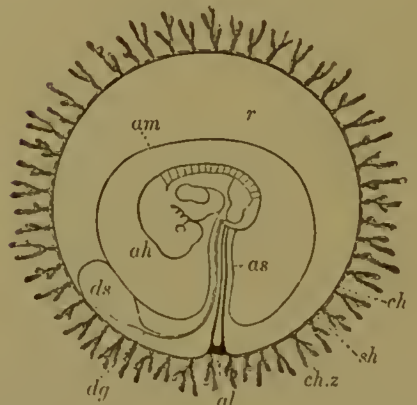
The Chorion differs much in various groups of the higher mammals: the following statements apply to the human race and the higher apes.

The primitive ovum has three coats (p. 74): the true vitelline membrane outside; next, the zona pellucida; and internally, a third indistinct layer. The outer and inner coats disappear before or soon after impregnation, but the zona pellucida remains distinct for some time (Figs. 54, 55, 56). It gradually thins away, however, and, soon after the subzonal membrane comes in contact with it, disappears (Fig. 57). The allantois quickly lines the whole subzonal membrane, and, fusing with it, forms a double coat enveloping the whole embryo: the outer layer of this coat is epiblastic and non-vascular and derived from the subzonal membrane; the inner layer is mesoblastic, vascular, and derived from the allantois. This double coat is the *chorion.*

The embryo at this stage has been for some time in the uterus, and, as it enlarges and the amnion becomes distended with liquid, comes to nearly fill the cavity of that organ: folds of the mucous membrane of the womb grow up over it and closely invest it.

About the fourth week the chorion is completed, and immediately large branched villi grow out all over its surface (Fig. 60), and imbed themselves in crypts or depressions which form in the uterine mucous membrane. These crypts are new formations and have nothing to do with the uterine glands.[1] Each of these villi has a vascular core of mesoblast derived from the allantois, and a covering of epithelium derived from the subzonal membrane.

Fig. 60.



(From Kölliker.) Diagrammatic Section of the Human Embryo after the allantois has spread all over the inside of the subzonal membrane, forming the true chorion, from which large branched villi are seen to radiate: *r*, cavity of false amnion or primitive amniotic cavity; *am*, true amnion; *as*, amniotic or somatopleuric stalk of umbilical cord; *ah*, cavity of true amnion; *ds*, umbilical vesicle; *dg*, umbilical duct; *al*, stalk of allantois; *ch.z*, chorionic villi; *sh*, subzonal membrane; *ch*, allantois lining subzonal membrane.

At the time when the chorionic villi appear three regions may be distinguished in the uterine mucous membrane. Parts of each are cast off with the after-birth, hence they are named decidua. They are represented at a little later stage in Fig. 61. To quote from Balfour:[2]

"There is (1) the part of the [mucous membrane] reflected over the [embryo and its appendages], called the *decidua reflexa*, *dr*; (2) the part of the [uterine mucous membrane] forming the area round which the reflexa is inserted, called the *decidua serotina*, *ds*; the general wall of the uterus not related to the embryo, called the *decidua vera*, *dv*."

"The decidua reflexa and serotina together envelop the chorion, the processes of which fit into crypts in them. At this period both of them are highly and nearly uniformly vascular. The general cavity of the uterus is to a large extent obliterated by the [embryo and its appendages], but still persists as a space filled with mucus between the decidua reflexa and decidua vera.

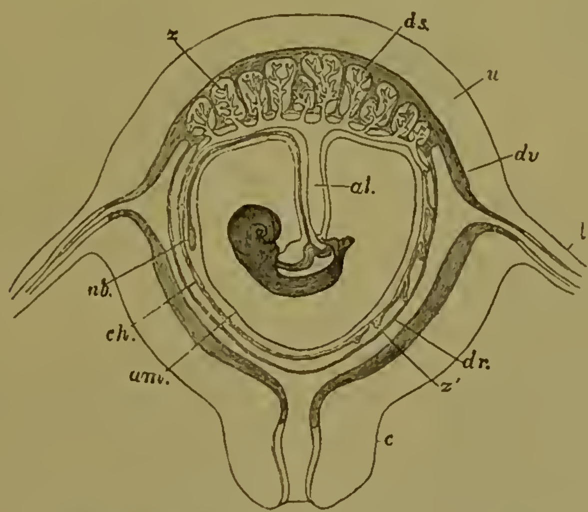
"The amnion (*am*) continues to dilate (its cavity being tensely filled with amniotic fluid) until it comes very close to the chorion; from

[1] In many mammals smaller and simpler villi grow out from the zona pellucida or subzonal membrane before the chorion is completed. According to Allen Thomson and Reichert, such villi are to be found on the human embryo a fortnight after impregnation; they soon give way to the true chorionic villi.

[2] *Comparative Embryology*, vol. ii. p. 203.

which, however, it remains separated by a layer of gelatinous tissue. The villi of the chorion in the region covered by the decidua reflexa gradually cease to be vascular, and partially atrophy, but in the region in contact with the decidua serotina increase and become more vascular and more arborescent (Fig. 61, *z*). The former region becomes known

FIG. 61.



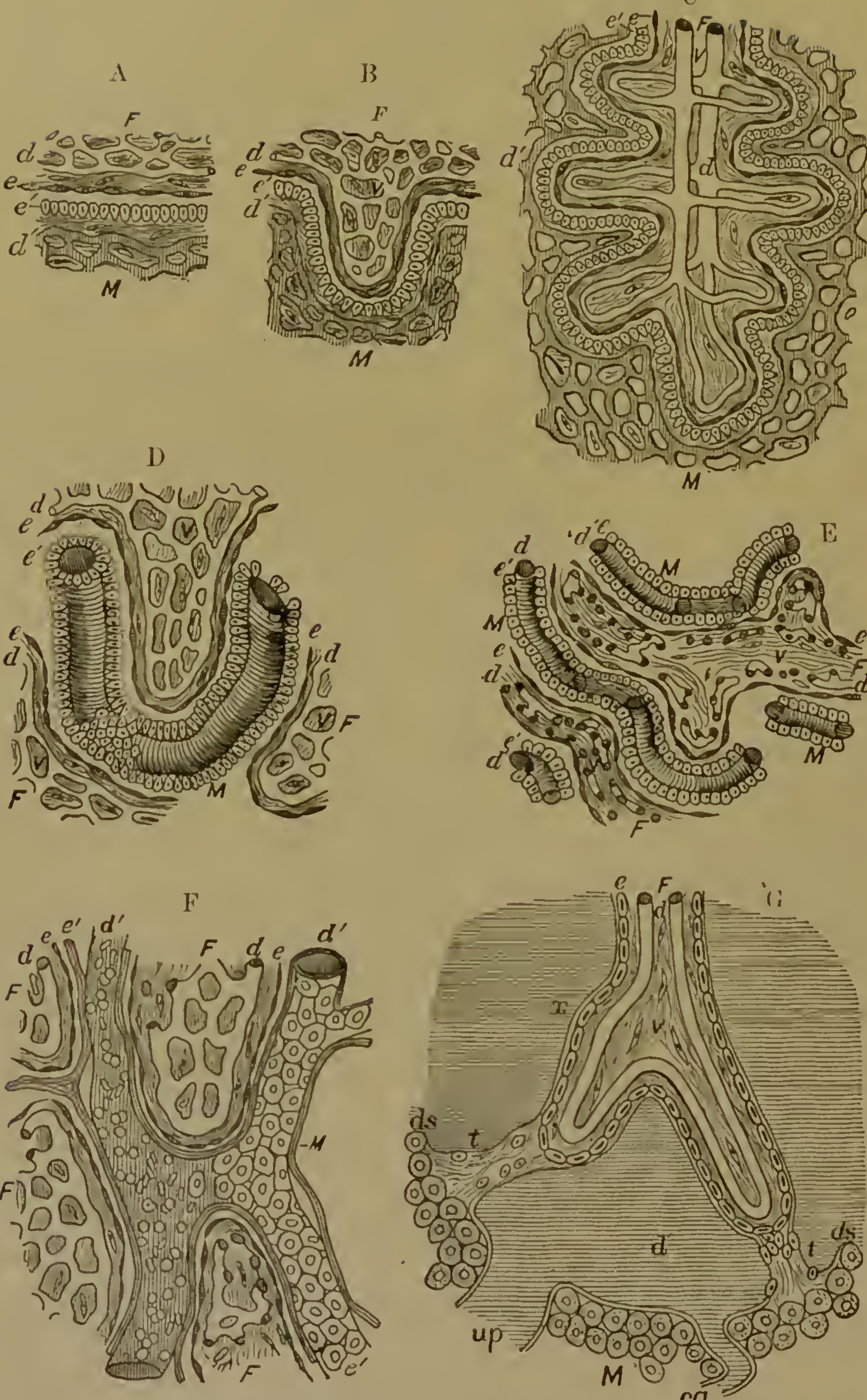
(From Huxley, after Longet.) Diagrammatic Section of Pregnant Human Uterus, with contained fœtus: *al*, allantoic stalk; *uv*, umbilical vesicle; *am*, amnion; *ch*, chorion; *ds*, decidua serotina; *dv*, decidua vera; *dr*, decidua reflexa; *l*, Fallopian tube; *c*, cervix uteri; *u*, uterus; *z*, fœtal villi of placenta; *z'*, villi of non-placental part of chorion.

as the *chorion læve*, and the latter as the *chorion frondosum*. The chorion frondosum, together with the decidua serotina, gives rise to the placenta. That part of the chorion which helps to form the placenta is distinguished as the *true chorion* from the remainder or *false chorion*.

"Although the vascular supply is cut off from the chorion læve, the processes on its surfaces do not completely abort. It becomes, as the time of birth approaches, more and more closely united with the reflexa, till the union between the two is so close that their exact boundaries cannot be made out. The umbilical vesicle (*uv*), although it becomes greatly reduced in size and flattened, persists in a recognizable form till the time of birth.

"As the embryo enlarges the space between the decidua vera and decidua reflexa becomes reduced, and finally the two parts unite. . . . . During the whole of pregnancy the decidua vera can, however, be distinguished by its structure, and remains highly vascular. The decidua reflexa becomes non-vascular, and fuses, as has been stated, on one side with the chorion and on the other with the vera. The membrane resulting from its fusion with the latter becomes thinner and thinner as pregnancy advances, and is reduced to a thin layer at the time of birth."

Fig. 62.



(From Balfour, after Turner.) A, placenta in its most generalized form; B, structure of placenta of pig; C, structure of placenta of cow; D, structure of placenta of fox; E, structure of placenta of cat; F, structure of placenta of sloth: on the right side of the figure the flat maternal epithelial cells are shown *in situ*: on the left side they are removed, and the dilated

The Placenta.—The human placenta is so highly specialized a structure that to understand it requires some previous study of simpler forms of the organ.

The placentæ of the higher mammals fall into two great groups—*deciduate* and *non-deciduate*. In the deciduate type the connection between the fœtal and maternal structures is so close that part of the uterine mucous membrane comes away with the after-birth; this is not the case in non-deciduate forms. There are several subsidiary varieties of both these main kinds of placentæ, known from their shape and arrangement as discoidal, zonary, diffuse, and so forth, but into the description of most of these we need not enter.

The placenta in all the higher mammals is, as we have seen, a compound organ, composed partly of fœtal structures (true chorion) and partly of maternal structures (decidua serotina). The function of the organ is to bring the fœtal blood into such close relationship with the maternal that the former may by diffusion give up its wastes to the blood of the mother, and receive similarly from that blood food and oxygen. There is in no case any actual mixing of the two bloods, the fœtal and maternal blood-vessels remaining quite distinct throughout.

The simplest conceivable form of placenta is indicated at A, Fig. 62, where *F* represents the fœtal, and *M* the maternal, portion; both are flat membranes closely applied: *d* represents the allantoic part of the chorion with its capillaries, and *e* the subzonal layer of the chorion reduced to a stratum of flattened cells. In the maternal part *e′* indicates the lining epithelium of the uterus, and *d′* the vascular corium of the uterine mucous membrane with its capillaries. In such a structure dialysis could take place, through the two epithelial layers, between the bloods in the fœtal and maternal vessels. Such a placenta would, however, afford but a comparatively small area for the interchange of materials; and none so simple is known.

If, however, the uterine surface became pouched, and the chorionic surface sent outgrowths into these pouches, the superficial area of contact of the two parts of the placenta would be greatly increased. The simplest known stage of this process is found in the pig (B, Fig. 62). The uterus of the sow develops a number of shallow crypts into which simple villi from the chorion grow.

The next stage in evolution may be illustrated by the placenta of the

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maternal vessel with its blood-corpuscles is exposed; G, structure of human placenta: *F*, fœtal, and *M*, maternal placenta; *e*, epithelium of chorion; *e′*, epithelium of maternal placenta; *d*, fœtal blood-vessels; *d′*, maternal blood-vessels; *v*, villus.

The succeeding references apply to G only: *ds*, decidua serotina of placenta; *t*, trabeculæ of serotina passing to fœtal villi; *ca*, curling artery; *up*, utero-placental vein; *x*, prolongation of maternal tissue on the exterior of the villus outside the cellular layer, *c′*, which may represent either the endothelium of the maternal blood-vessel or the delicate connective tissue belonging to the serotina, or both; the layer *c′* represents maternal cells derived from the serotina. No layer of fœtal epithelium can be recognized on the villi of the fully-formed human placenta.

cow (C, Fig. 62), in which the uterine crypts and the chorionic villi have both become branched, thus affording a more extensive surface for the diffusion processes between the bloods of the embryo and the mother.

The placentas of the pig and cow are non-deciduate, and two layers of epithelium (one fœtal and one maternal) separate the allantoic and uterine vessels. The maternal vessels are in both cases capillaries.

In deciduate placentas a further advance is made. In the fox and cat (D, E, Fig. 62) the maternal capillaries become greatly dilated, and, covered by a little connective tissue and by a layer of uterine epithelium, *e'*, form an anastomosing network within which the fœtal villi twine. The surface for mutual diffusion is thus greatly increased.

In the sloth (F, Fig. 62) the maternal capillaries are still more dilated, and the epithelium covering them has become flattened instead of columnar, so that a still thinner membrane is interposed between the bloods of embryo and mother.

In the human placenta (G, Fig. 62) and in that of apes we find a higher evolution. The maternal vessels dilate into large sinuses, *d'*, which freely intercommunicate. Blood is conveyed abundantly to these sinuses by enlarged uterine arteries, and carried off from them by the dilated veins of the pregnant womb. The branched fœtal villi of the true chorion project into these sinuses, and, bathed on every side by the flowing maternal blood, for the most part hang freely within them. The villi are, however, sometimes attached by cords (*t*) to the walls of the sinus. In the later stages of embryonic life there is only one layer of epithelium between the maternal and the fœtal blood. This closely invests the fœtal villi, but is derived from the uterus, the original subzonal epithelium of the chorion having disappeared.

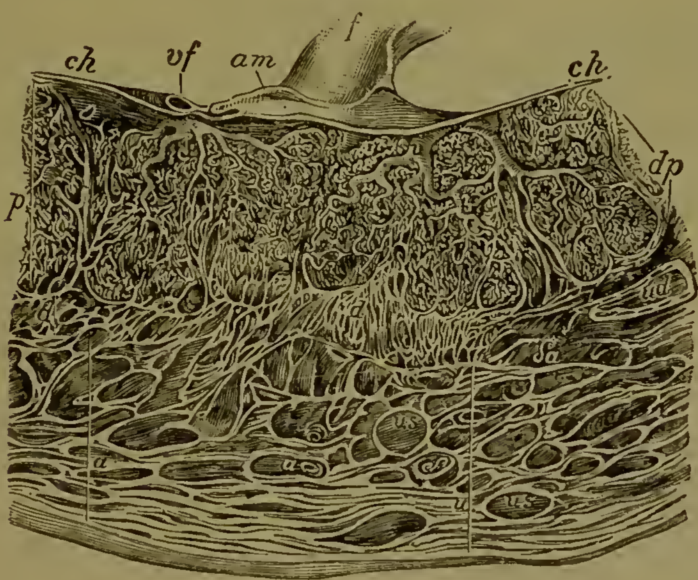
The human placenta, when fully developed, is a discoid[1] organ, slightly convex on its outer and concave on its inner surface. It develops normally on the ventral side of the embryo, and, so far as its fœtal portion is concerned, from that region of the allantois which lies in the neighborhood of the allantoic stalk. It is usually circular or oval in outline, and varies considerably in size. A full-sized oval placenta measures 7–7½ inches (17.8–19 centimeters) in its shorter and 8–9½ inches (20.5–24.0 centimeters) in its longer diameter. The thickness is generally greatest opposite the point of entrance of the umbilical or allantoic stalk, where the organ measures 1–1¼ inches (2.5–3.2 centimeters); it becomes gradually attenuated toward the margin, which is

[1] The placenta of Rodentia, Insectivora, and Cheiroptera is also discoidal in form, but differs in several important respects, as regards development, from that of man and apes. Comparative embryologists reserve the name discoidal for the rodent type, and name the human type meta-discoidal. (See Foster and Balfour, *Elements of Embryology*, p. 353 *et seq.*)

slightly rounded, measuring here only 2–4 lines (4–7 millimeters) in thickness (Farre). At its margins it is continuous with both the decidua vera and the decidua reflexa (Figs. 61 and 64).

The amniotic sheath of the umbilical cord is shown in Figs. 57 and 60 as having extended a considerable distance along the allantoic stalk, but as not yet having reached the inner surface of the chorion. This it ultimately does, and the amnion then spreads out on all sides over the chorion frondosum, and, adhering closely to it, forms the inner or

Fig. 63.



Vertical Section of Uterus, with placenta attached (from a woman in the thirtieth week of gestation; from Farre, after Wagner). The lines *uu* indicate the thickness of the uterine wall outside the decidua serotina; *dp*, the decidua serotina, or placenta; *p*, the thickness of the rest of the placenta (toward the right of the figure the serotina is separated into *ud*, uterine serotina, and *dp*, decidual serotina, with its septa passing up among the chorionic villi); *f*, umbilical cord; *am*, amnion; *ch*, chorion; *vf*, fœtal blood-vessel on surface of placenta cut across; *vv*, chorionic villi; *us* and *a*, dilated uterine blood-vessels.

fœtal surface of the placenta. At the margins of the placenta it turns back to envelop the embryo. A section through the placenta (Fig. 63) therefore shows the amnion (*am*) as forming its innermost layer,

Immediately external to the amniotic layer comes the chorion (*ch*), from whose outer surface the very numerous, greatly-branched, tortuous villi (*v*) project: these villi soon lose their proper epithelium derived from the subzonal membrane (p. 132); the structure of their terminal branches has been shown in G, Fig. 62. The allantoic arteries reaching the chorionic layer through the umbilical cord (*f*) ramify in this layer in the form of a number of large branches which spread over it just beneath the amnion: one of these branches is represented cut across at *vf*. The terminal branches of the arteries when they have become reduced to the size of a crowquill suddenly dip down from the surface and enter the villous layer. The larger trunks also, as they diverge, give off branches from their deeper sides which supply the villi. The veins, returning the fœtal blood, have a course similar to the arteries: the larger trunks converge toward the funis, and there

Fig. 64.

(From Allen Thomson.) Diagrammatic Representation of a Section of the Human Placenta, near the margin, at five or six months: *am*, amnion; *ch*, chorion: from its under surface the branched villi are seen to project; *m*, muscular coat of uterus with divided blood-vessels; *v*, decidua vera; *r*, decidua reflexa; *s*, placental serotina; *s'*, uterine serotina; *ds*, septa of placental serotina separating the lobes of the placenta: near their bases are seen the coiled arteries; *cs*, circular sinus, a great vein which runs around the margin of the placenta.

enter the umbilical (allantoic) vein.[1] In the villi the arteries and veins are connected by a capillary network.

The amniotic layer and the chorionic layer, with the villi and blood-vessels of the latter, constitute the fœtal portion of the placenta.

Soon after the chorion frondosum comes in contact with the decidua serotina the inner stratum of the latter becomes greatly modified. It loses its lining epithelium, and the superficial portions of the uterine glands previously contained in it disappear.[2] This layer of the serotina thus becomes a mere vascular fibrous membrane. The lower ends of the glands still remain intact in the deeper layer of the serotina (*ud*, Fig. 63). During parturition the superficial non-glandular serotina is shed as a part of the placenta, while the deeper glandular layer remains to renew the

[1] For a more detailed description of the arteries and veins of the placenta see Farre in *Todd's Cyclopædia*, supplementary volume, p. 716.

[2] If, as is probable, Pflüger's theory of menstruation (p. 94) be correct, the epithelium and the superficial portions of the glands are shed before the embryo reaches the uterus.

uterine lining, the new epithelium spreading out from the mouths of the glands much as after an ordinary menstruation (p. 84). That portion of the serotina which is intimately associated with the fœtal structures, and is shed with them, is distinguished as the *placental* from the other or *uterine* layer. Toward the right of Fig. 63 these two layers are indicated as *dp* and *up* respectively, but they are more clearly shown in the diagram, Fig. 64.

When the placenta is detached after a normal labor its outer surface is seen to consist of a thin, soft, tough layer marked out by furrows into numerous oval or angular areas varying from half an inch to an inch and a half in diameter. From the boundaries between these areas septa of connective tissue (*dp*, Fig. 63, and *ds*, Fig. 64) pass into the villous stratum of the placenta and subdivide it into numerous lobes or *cotyledons*. From the sides of the septa connective-tissue cords ramify and intertwine with, support, and in many places adhere to the chorionic villi. The surfaces of the cords and villi are everywhere covered by a single layer of epithelium cells.

The substance of the placenta, from the chorion inside to the placental serotina outside, is thus a loose, spongy mass, traversed in all directions by chorionic villi and by bands of connective tissue; and the cavities of the sponge are everywhere lined by an epithelium. These cavities are the *blood-sinuses* through which the maternal blood flows to bathe the fœtal villi (p. 136). The uterine arteries (*a*, Fig. 63) outside the decidua enlarge while the placenta is developing, and become somewhat twisted. Passing in, they branch in the uterine serotina, and then enter the placental serotina, and, becoming spirally coiled (see Fig. 64), enter its septa. Branching somewhat in these septa, the arteries finally open into the blood-sinuses, their epithelium being continuous with, and passing into, those lining the sinuses: the latter are, in fact, enormously-dilated capillaries closely investing the fœtal villi on all sides, one capillary wall, represented by the cells *c′* (G, Fig. 62), adhering to each villus.

From the sinuses the blood is collected directly by veins which open into them, and is carried away from the womb in the main uterine veins.

When the placental serotina separates from the uterine during parturition the arteries and veins are ruptured at the contact of the two layers; but in normal conditions the contraction of the womb quickly closes them, and no great amount of bleeding results.

The decidua reflexa and decidua vera, which are continuous with the placenta (Fig. 61, 64), are discharged with it as part of the after-birth.[1]

[1] For details as to the histology of the placenta consult Minot, in the *Reference Handbook of the Medical Sciences*. Minot's description differs from that above given; he believes that the epithelium of the chorionic villi in advanced stages of pregnancy is fœtal and not maternal in origin.

V. The Development of some of the more Important Organs and Systems.

The Development of the Spinal Column.—The notochord arises in the mammal, as in the chick (Figs. 25, 26, 27), from hypoblast cells, and forms a rod separated by a clear space containing only liquid (p. 108) from the peripheral plates of the mesoblast. Its anterior end reaches forward to the region where the body of the sphenoid will be developed later. As the embryo grows by additions to its posterior end, the notochord also elongates; it reaches as far back as the tip of the future coccyx. In Mammalia it is from the first constricted at intervals, each constriction in the vertebral region corresponding in position to the body of a future vertebra.

Fig 65.

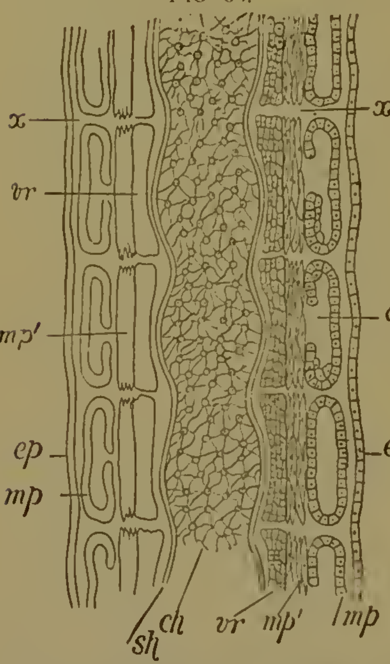
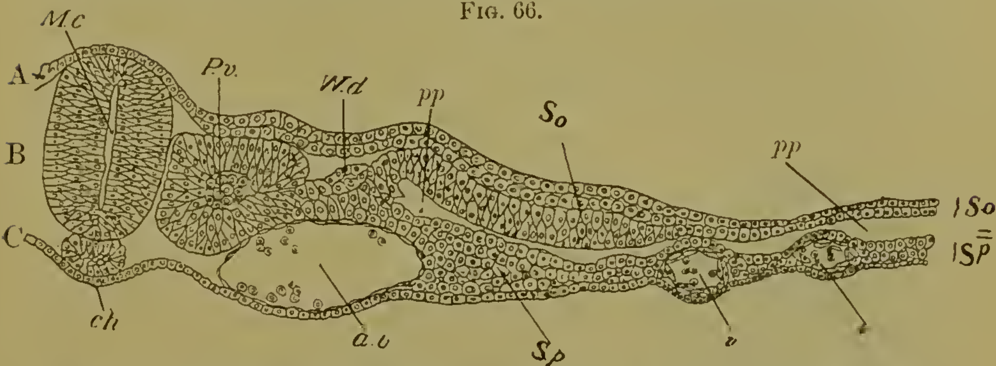


Diagram of a Horizontal Section through an Embryo at the level of the notochord, and after the mesoblastic somites have commenced to differentiate: *ch*, reticular notochord, constricted at points which correspond in position to the centra of the future vertebræ; *sh*, sheath of notochord; *mp*, outer portion of muscle-plate; *ca*, its cavity; *mp'*, inner part of muscle-plate, commencing to form the longitudinal muscles of the trunk; *vr*, inner part of mesoblastic somite which will give rise to the bodies of the vertebræ and the greater portion of the intervertebral disks; *ep*, epiblast on outer surface of embryo.

The notochord cells are at first rounded and solid, but they quickly become greatly vacuolated, and form a spongy reticulum with nuclei scattered here and there throughout it (*ch*, Fig. 65). Around the rod a structureless sheath, *sh*, is excreted by its cells.

The mesoblast, as has been pointed out (p. 107 and Fig. 30), spreads as a peripheral plate from each side of the notochord between the epiblast and hypoblast. When it cleaves into its outer (somatopleuric) and inner (splanchnopleuric) layers the cleavage at first extends close up to its central margin, near the notochord. While the outer part of the cleft widens rapidly to form the pleuroperitoneal and primitive amniotic cavities, the inner part remains narrow (Fig. 36), and, in fact, for a time disappears entirely. The mesoblast then thins away from above down on each side in a line parallel with the notochord (Fig. 66), and nearer to it than the commencing dilation of the pleuroperitoneal cavity, *pp*. There is thus incompletely separated a more mesial solid plate of mesoblast, *Pr*, from a more peripheral cleft-plate: the former is the *vertebral plate*, the latter the *lateral plate*. At this stage the vertebral plate is seen to possess a core of central cells different from those on its outside. The cells above this core are continuous with the somatic layer of the lateral plate, and the cells below it with the splanchnic layer.

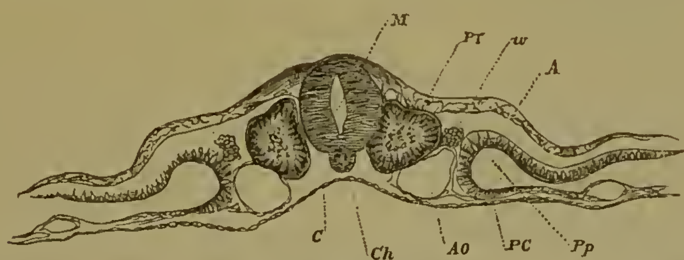
Fig. 66.



(From Foster and Balfour.) Transverse Section through the Dorsal Region of an Embryo (chick) after forty-five hours' incubation: A, epiblast; B, mesoblast; C, hypoblast; *M.c*, neural canal, closed in; *P.v*, cross-section of vertebral plate; *pp*, commencing pleuroperitoneal cavity in lateral plate: between the vertebral and lateral plates the mesoblast is seen to be thinner than elsewhere; *So*, somatopleure; *Sp*, splanchnopleure; *ch*, notochord; *a.o*, one of the dorsal aorta: at this stage there are two in this region of the embryo; *v*, blood-vessels of splanchnopleure; *W.d*, cross-section of Wolffian duct.

Very soon (Fig. 67) the vertebral plate separates entirely from the lateral plate, and forms a rod on each side of the neural canal. This rod almost immediately commences to divide transversely at short intervals, and thus becomes cut up into a number of cuboidal pieces (Figs. 29 and 68), which lie on each side of the neural canal. The cross-divisions do not occur or are indistinct in the region which will

Fig. 67.

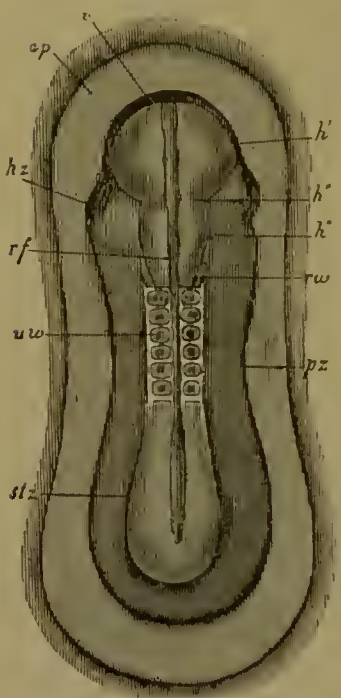


(From His.) Cross-section of Dorsal Region of Chick Embryo at a little later stage than Fig. 66: *M*, neural canal; *Pr*, cross-section of vertebral plate; *A*, epiblast; *C*, hypoblast; *Ch*, notochord; *Ao*, aorta; *Pp*, pleuroperitoneal cavity; *w*, rudiment of Wolffian duct.

ultimately form the head: the first well-marked pair appears at about the level of the second cervical vertebra; another soon develops in front of this; and then, as the embryo elongates by additions to its posterior end, the vertebral plates, increasing in length with it, divide farther and farther back into a series of pieces corresponding in number to the future vertebræ. These pieces are known as the *mesoblastic somites.* Each consists at first of an outer layer of large columnar cells and of a core of smaller rounded cells.

As the embryo grows and its body-walls fold in more and more, its depth or thickness from the epiblast covering in its dorsal region to the hypoblast on its under surface increases considerably, and the mesoblastic somites grow rapidly. They extend upward around the neural canal, and meet from each side above it, thus separating the canal from contact with the external epiblast. They also grow inward below the neural canal, between it and the notochord and between the latter and the hypoblast. The notochord thus acquires a close investment of mesoblast cells. These changes are indicated in Fig. 69, which should be compared with Figs. 66 and 30. Meantime each mesoblastic somite differentiates into an upper outer portion (*mp*, *mp′*, Figs. 65 and 69), the *muscle-plate*, and an inner or *vertebral portion*, from which the spinal column and its ligaments are ultimately formed.

Fig. 68.



(From Kölliker.) Rabbit Embryo eight days and fourteen hours after coition, viewed from above and magnified nearly 28 diameters. Six mesoblastic somites have developed: *ap*, area pellucida; *r*, anterior border of head; *h′*, fore-brain; *h″*, region in which mid-brain will develop later; *h‴*, commencement of hind-brain; *uw*, mesoblastic somites.

The original narrow cleft in the mesoblast of each vertebral plate (p. 116), which had become indistinguishable, now reappears (*ca*, Figs. 65 and 69) for a brief time in each muscle-plate. In Fig. 65, which represents a horizontal section through several somites of the embryo at the level of the notochord, it is seen that these cavities lie in a row on each side, one for each somite. The mesoblast cells (*mp′*) on the inner side of the cavity rapidly elongate, and give origin to longitudinal muscle-fibres running the whole length of the neck and trunk of the embryo. These muscles are at first, as is obvious from Fig. 65, segmented, being interrupted at the spaces, *x*, between the somites. This condition is permanent in many of the lower vertebrates (fishes), but is soon obscured in mammals by fusion end to end of the muscles of neighboring somites. The outer portion of the muscle-plate (*mp*, Figs. 65 and 69) also becomes ultimately converted into muscles, and all traces of the original cavity are lost. All the voluntary muscles of the head, neck, and trunk are ultimately developed from extensions of the muscle-plates: probably the same is true of all the skeletal muscles of the body, though it is still uncertain as regards the mammals whether the muscles of the limbs do not arise independently: the origin of the diaphragm is also as yet undetermined.

The vertebral portion of each mesoblastic somite (*vr*, Figs. 65 and 69) when it first envelops the neural canal and notochord is separated by a cleft from the somites in front of and behind it. These interspaces are soon obliterated, and the notochord thus obtains a continuous unsegmented mesoblastic sheath. The cleft separating the vertebral from the lateral plate, which was nearly vertical in an earlier stage (Fig. 67), has by this time (*y*, Fig. 69) become nearly horizontal on account of

FIG. 69.

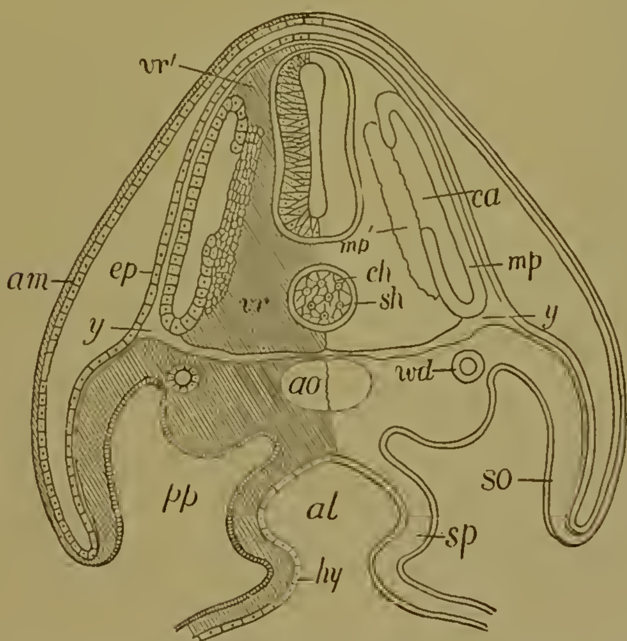


Diagram of Cross-section of Dorsal Region of an Embryo shortly after the differentiation of the muscle-plates (to be studied in connection with the horizontal section, Fig. 65): *mp*, outer layer of muscle-plate; *mp'*, inner layer of muscle-plate, giving origin to longitudinal muscles; *ca*, cavity of muscle-plate; *ch*, notochord; *sh*, sheath of notochord; *vr*, vertebral portion of mesoblastic somite; *vr'*, its upward extension (*neural plate*) to surround the neural canal: the vertebral portion will be seen to have grown to the middle line below and enveloped the notochord; *ep*, epiblast; *hy*, hypoblast; *so*, somatopleure; *sp*, splanchnopleure; *al*, alimentary canal; *pp*, pleuroperitoneal cavity: the mesoblast cells lining it are already developing the epithelium of the future pleural and peritoneal cavities; *wd*, Wolffian duct; *y*, cleft between mesoblastic somite and lateral plate; *am*, true amnion: this is omitted in Fig. 65.

changes in the relative sizes and positions of different parts of the embryo: this cleft also becomes obliterated at a later stage in development, and the lateral and vertebral plates again become continuous (Fig. 79).

The unsegmented mesoblastic sheath of the notochord through its upper extensions, or *neural plates* (*vr'*, Fig. 69), provides a continuous envelope for the neural canal. This condition gives place to the *secondary segmentation* of the spinal column by which the vertebræ are separated from one another; but the *new segments are opposite the inter-*

vals between the former.[1] The mesoblast immediately around the notochord becomes cartilaginous at intervals, and forms a number of nodules which encroach on and constrict the notochord (Fig. 70). Each nodule arises opposite one of the division lines (x, Fig. 65) between the original somites, and is the rudiment of the centrum of a vertebra. The tissue between the nodules becomes fibrous and forms ultimately an intervertebral disk. Almost simultaneously the neural plates (rr', Fig. 69) become cartilaginous at intervals corresponding to the rudiments of the vertebral bodies; and these cartilages, joining the centra below and meeting over the neural canal above, are the rudiments of the neural arches of the vertebræ. The mesoblast of the neural ridge between the neural arches gives origin to the ligaments uniting them; the inner layer of the ridge nowhere becomes cartilaginous, but develops into the perichondrium, periosteum, and dura mater.

Fig. 70.

(From Kölliker.) Magnified Horizontal Longitudinal Section through several Thoracic Vertebræ of a Human Embryo of eight weeks: *v*, cartilaginous vertebral centrum; *li*, intervertebral ligament; *ch*, remnant of notochord.

The modification of mesoblast cells surrounding the notochord into cartilage, occurs about the fourth or fifth week in the human embryo, and the chondrification of the neural arches almost simultaneously. Ossification commences about the eighth week from three centres—one in the body and two in the neural arch. The first vertebra to ossify is the second or third cervical.

When ossification is completed the notochord is entirely obliterated in the vertebral centra, but a modified residue of it may be found throughout life as the *nucleus pulposus* of the intervertebral disk.

It would carry us beyond the limits of the space at our disposal to describe in detail the embryology of the rest of the skeleton. Some account of the origin of the facial skeleton will, however, be given later (p. 185).

The Development of the Limbs.—The limbs arise as lateral outgrowths of the mesoblast and epiblast of the somatopleuric layer of the

[1] "The explanation of this character in the segmentation is not difficult to find. The primary segmentation of the body is that of the muscle-plates, which were present in the primitive forms in which vertebræ had not appeared. As soon, however, as the notochordal sheath was required to be strong as well as flexible, it necessarily became divided into a series of segments.

"The condition under which the lateral muscles can best cause the flexure of the vertebral column is clearly that each myotome [segment of longitudinal muscle] shall be capable of acting on two vertebræ; and this condition can only be fulfilled when the myotomes are opposite the intervals between the vertebræ" (*Balfour*).

lateral plates at positions which correspond to the future pectoral and pelvic arches. They appear in the human embryo as somewhat flattened outgrowths about the fourth week after conception. If the dia-

FIG. 71.

FIG. 72.

FIG. 71.—(From Allen Thomson.) Lateral View of Human Embryo between three and four weeks: AM, amnion surrounding the embryo; UV, umbilical vesicle; AL, stalk of allantois; AE, rudiment of arm; PE, rudiment of leg.

FIG. 72.—(From Allen Thomson, after His.) Outlines of the Anterior Extremity of Human Embryos at different ages: A, at four weeks; B, at five weeks; C, at seven weeks; D, at nine or ten weeks.

gram (Fig. 69) represented a cross-section in the region of the origin of the limbs, they would be indicated as outgrowths of the somatopleure a short way below the line of reference leading from the letter *y*.

The first semilunar outgrowth (AE, PE) which represents a limb develops into the manus or pes. A stalk developed between it and the trunk region becomes the rest of the arm or leg. This stalk is first

FIG. 73.

(From Allen Thomson.) Diagrammatic Outline of a Human Embryo of about seven weeks, to show the primitive relations of the limbs to the trunk: R, the radial (pre-axial), and U, the ulnar (post-axial) border of the hand and forearm; T, the tibial (pre-axial), and F, the fibular (post-axial) border of the foot and lower leg.

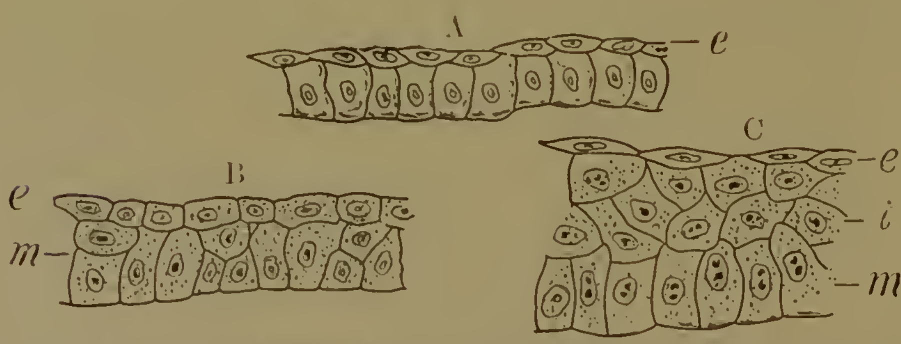
separated by a constriction from the foot or hand, and later subdivided into *antebrachium* and *brachium*, or *crus* and *femur*. The progress of development in the case of the fore limb is shown in Fig. 72. While the changes which give rise to forearm and arm and crus and thigh are occurring, the first formed and peripheral segment of the limb presents four notches (D, Fig. 72), which indicate its subdivision into five digits.

The crescentic outgrowths which are the first rudiments of the limb are thin plates presenting a dorsal and a ventral surface. The dorsal surface corresponds to the future extensor surface of each limb, and the ventral to the flexor, and the thumb and great toe are at first on the forward or pre-axial side (Fig. 73), as are also the radial and tibial bones when they appear: the radius and tibia are therefore *pre-axial* as compared with the embryonic ulna and fibula, which are *post-axial.* The elbow- and knee-joints of the early embryo flex toward the trunk: their subsequent directions of movement are due to a partial rotation of each limb, which results in making the elbow bend ventrally and the knee-joint dorsally.

The Development of the Skin and its Appendages.—The skin has a double origin. Its deeper layer, the *cutis vera*, consisting of connective tissue, blood-vessels, and lymphatics, is formed by modification of mesoblast cells lying immediately under the epiblast: its superficial layer, the *cuticle* or *epidermis*, and all hairs, nails, and the secretory cells of cutaneous glands, originate from the embryonic epiblast.

In all the higher vertebrates the external epiblast, which at first consists of a single layer of cells, becomes two-layered (Fig. 74, A): the

Fig. 74.



(From Haddon, after Jeffries.) Sections of Developing Epidermis of Bird Embryos: A, vertical section of chick embryo after one hundred and eleven hours' incubation; B, the same after one hundred and thirty-four hours' incubation; C, section through epidermis of duck after seventeen days of incubation; *e*, epitrichial layer; *m*, Malpighian layer; *i*, transitional layer.

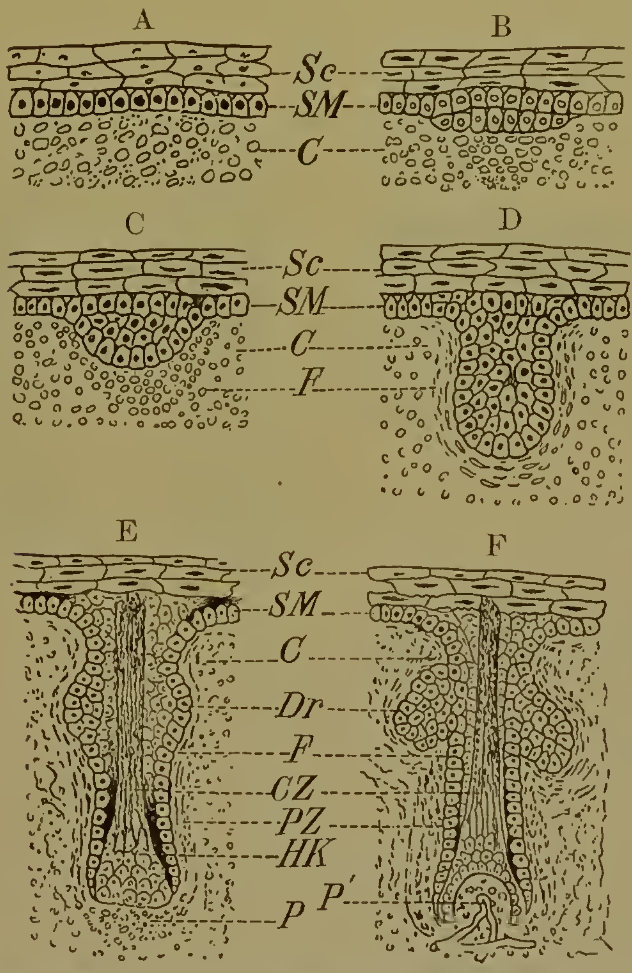
outer layer, *e*, becomes flattened and forms the *epitrichial layer*, which is shed before birth. Minot[1] has shown that this layer can be found in the human embryo about the fourth month of intra-uterine life. It encloses beneath it the secretion of the embryonic sebaceous glands, and thus causes the accumulation of the vernix caseosa.

After the epitrichial layer has been formed, the deeper cells of the

[1] *American Naturalist*, 1886.

epiblast multiply and form an epidermis several layers of cells in thickness. The superficial cells, becoming horny and dead (*stratum corneum*, Fig. 75), are shed throughout life, while the deeper cells multiply and replace them: the deeper-placed living epidermic cells constitute the so-called *Malpighian* or *mucous layer*, *SM*. A true horny layer of the epidermis develops only in terrestrial vertebrates.

Fig. 75.



(From Wiedersheim.) Six Stages in the Development of a Hair: *Sc*, *stratum corneum* of the epidermis; *SM*, stratum Malpighii; *C*, dermis; *F*, hair-follicle in different stages of development; *CZ*, rudiment of hair; *PZ*, rudiment of epithelium of hair-follicle; *P*, commencement of papilla; *P′*, papilla more advanced and after it has become vascular.

Hairs.—Every hair commences as an ingrowth of the Malpighian layer of the epidermis, reaching down into the dermis as a solid rod of cells. This rod dilates at its deeper end (E, Fig. 75), and then a vascular dermic papilla extends into it (F). Meanwhile, the primitive continuous cylinder (D) of epidermic cells divides concentrically into an inner core and an outer epidermic sheath (E, F). The cells of the core form the hair, which ultimately breaks through the horny layer of the epidermis and projects beyond it (Fig. 76). The cells of the sheath give origin to the lining of the hair-follicle. For the final structure of this and of the hair a treatise on histology must be consulted.

The first rudiments of hairs may be detected toward the close of the third month in the human embryo. They break through the horny layer of the epidermis (Fig. 76) during the fifth month of intra-uterine

Fig. 76.

(From Kölliker.) Developing Hair of Eyebrow, magnified fifty diameters. In A: *a*, horny layer of epidermis; *b*, Malpighian layer of epidermis; *m*, commencing hair.
In B, the letters of reference as before: in addition, *c*, cells which will form the external root-sheath; *i*, limiting membrane; *h*, dermic papilla; *e*, swollen lower end of hair-rudiment; *f*, stem, and *g* apex, of future hair; *n*, *n*, commencing sebaceous glands.
In C, the hair represented just after it has burst through the horny layer of the epidermis and protruded from its follicle.

life: the hairs of this first crop (*lanugo*) are for the most part shed before birth, and may be found floating in the amniotic liquid and imbedded in the *vernix caseosa*.

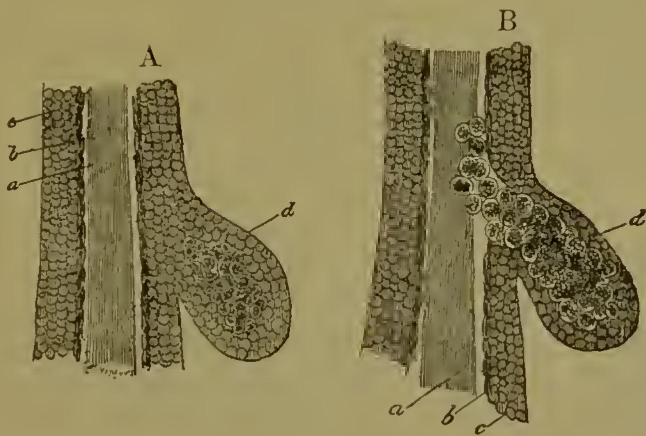
According to Kölliker, all the hairs of a newborn infant are shed and replaced during the first few months of extra-uterine life, those of the general surface being first cast off, and later (about twelve months after birth) those of the scalp and the eyelashes.

The Sweat-glands at their origin are at first much like rudimentary hairs: they consist of a cylinder of cells from the Malpighian layer of the epidermis which burrows down into the dermis, and becomes there twisted and expanded at its deeper end. Around the epidermic cylinder the dermis forms connective tissue and blood-vessels, and the rod of epidermic cells becomes hollow, forming the lumen of the gland. At first the glands are closed externally by the horny layer of the epidermis, but they subsequently open through it.

The ceruminous glands of the external auditory meatus are, judging from their development in the embryo, only modified sweat-glands.

The Sebaceous Glands almost invariably arise as outgrowths from the epidermic layer of the root-sheath of a hair (*Dr*, Fig. 75). At a somewhat later stage (Fig. 77) each is seen to form a flask-shaped appendage

FIG. 77.



(After Kölliker.) Illustrating Development of a Sebaceous Gland: *a*, hair; *b*, inner root-sheath; *c*, outer root-sheath of hair-follicle; *d*, rudiment of sebaceous gland, its central cells having already undergone fatty degeneration.

to a hair-follicle. The central cells of this appendage undergo fatty degeneration, and this extends along the axis of the neck of the gland. Ultimately, the degeneration reaches and breaks through the root-sheath of the hair, and the cavity thus left becomes the duct of the gland. Throughout life the cells lining the ultimate recesses of the gland undergo a similar fatty degeneration, and, breaking down, are discharged as the sebaceous secretion. The preputial and Meibomian glands are modified sebaceous glands.

The Mammary Glands, so characteristic of Mammalia, are probably specially-developed but modified sebaceous glands: they arise in the embryo much as the sebaceous glands do, and their secreting cells during lactation undergo the same sort of fatty degeneration.

The Development of the Nervous System.—The origin of the rudiments of the cerebro-spinal axis from the thickened epiblast of the medullary groove has already been described, as also the subsequent infolding of the sides of the groove to enclose the medullary canal. From the lining cells of this canal and their direct descendants are developed all the essential parts (nerve-cells and nerve-fibres of the nervous system), and in addition the supporting tissue (neuroglia) of the main nerve-centres. The retina is an offshoot of the primitive neural canal; the peculiar "end-organs" of the sensory fibres in other organs of special sense, though derived from the epiblastic layer of the embryo, do not arise from the involuted epiblast of the neural canal, but from the general external epiblastic layer.

All true nerve-tissues of the body develop from the epiblast, not only in man, but in all multicellular animals: put in another form, we may say that the primitive external layer of the gastrula (p. 109), which places organisms which continue throughout life as mere gastrulæ (*e. g.* hydra) in immediate relations with their environment, is the layer which develops the essential parts of the sense-organs, of the nerve-fibres, and the nerve-cells of more complex animals.

The Development of the Spinal Cord.—When the neural canal is first closed in, the brain is nearly as long as the spinal cord: the latter, however, quickly increases in relative length, while the embryo is growing, as it does at first, mainly by additions to its posterior end.

Fig. 78.

(From Kölliker.) Human Embryo of three months, natural size (the brain and spinal cord exposed): *h*, cerebral hemisphere; *m*, mid-brain; *c*, cerebellum: behind the latter are seen the medulla oblongata and the spinal cord, the latter reaching to the tip of the coccyx.

At the time of the formation of the most posterior mesoblastic somite the spinal cord is well marked, and has already attained some of its permanent external characters. In the human embryo (as first pointed out by Ecker[1]) it extends beyond the last coccygeal vertebræ for a time (Fig. 78). The extension of the spinal cord along the whole spinal canal is permanent in many animals, but in the human fœtus the spinal column elongates more rapidly than the spinal cord, so that the latter ultimately extends only so far as the upper lumbar region, and the roots of the spinal nerves come to pass more and more obliquely backward as they are farther distant from the head, because their intervertebral foramina have relatively shifted backward in consequence of the elongation in that direction of the spinal column: in this way the *cauda equina* is produced by a sort of dragging backward of the lumbar and sacral spinal roots, in order that they may reach their foramina of exit. The cervical and lumbar enlargements of the spinal cord appear about the end of the third month.

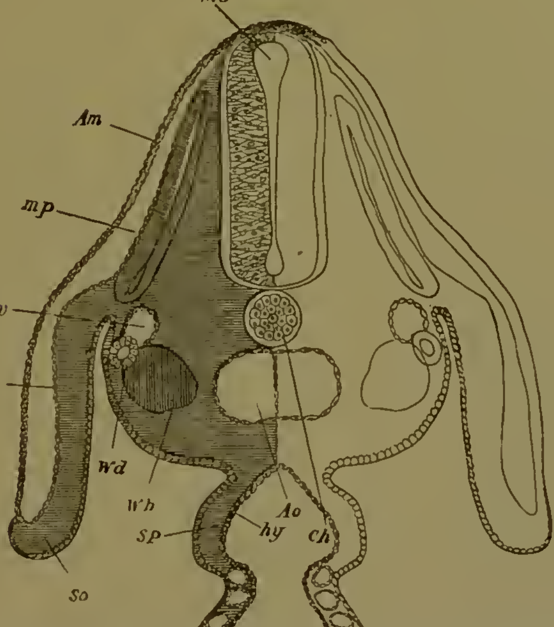
When the neural canal in the spinal region is first completely closed in, it presents the form (Fig. 32) of an oval tube; its walls are fairly uniform in thickness throughout, and consist of several rows of cells.

[1] *Icones physiologicæ*, 2d ed.

Soon after this the cord and its central canal become elongated dorso-ventrally. Fig. 79, taken from a chick embryo at the end of the third day of incubation, illustrates this stage.

In the adult spinal cord we find (*a*) the ciliated epithelium lining the central canal; (*b*) the gray matter, with its nerve-cells and medullated and non-medullated nerve-fibres; (*c*) the white matter, composed essentially of medullated fibres. The origin of these parts from the primitively uniform cells forming the spinal portion of the neural tube has not yet been satisfactorily made out. It is, however, probable that

Fig. 79.



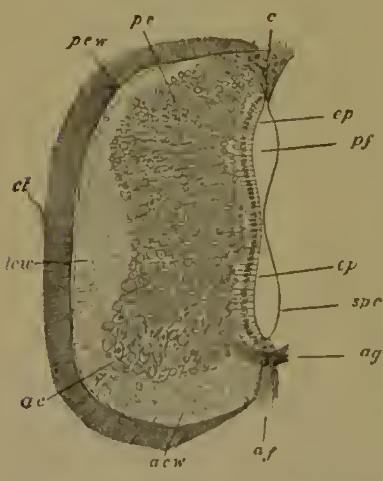
Transverse Section through Dorsal Region of a Chick Embryo at the end of the third day of incubation (from Balfour; semi-diagrammatic); *Am*, amnion; *mp*, muscle-plate; *cv*, cardinal vein; *Ao*, dorsal aorta: the section passes through the point of bifurcation of the aorta; *ch*, notochord; *Wd*, Wolffian duct; *Wb*, Wolffian body; *ep*, epiblast; *so*, somatopleure; *SP*, splanchnopleure; *hy*, hypoblast.

the ciliated lining cells correspond to the epitrichial layer of the epiblast (p. 146); that the nerve-cells and their processes (the axis-cylinders of nerve-fibres) are developed from an epiblastic layer equivalent morphologically to that which gives rise to the Malpighian layer of the epidermis; and that the peculiar supporting tissue of the spinal cord and brain (neuroglia) is the representative of the horny layer of the epidermis.

As usually described, after the differentiation of the lining cells of the *canalis centralis* the cells immediately outside it multiply rapidly and give rise to the nerve-cells and fibres of the gray matter. This cell-multiplication occurs mainly in the deepest stratum next the epithelium of the central canal, much as is the case in the growth of the epidermis from the deeper-placed cells of its Malpighian layer; but in the spinal cord the horny cells are from the first differentiated as the neuroglial network, and do not give rise to a special stratum as in the epidermis. Since the neural tube is but an involuted layer of the skin, and the cells lining its canal correspond to the primitive outer layer of the epidermis, it seems not improbable that it may ultimately be found that the cells of the developing gray matter multiply chiefly on its outer side (= deeper surface of epidermis), and that some of them give rise to the neuroglia (= inner) but morphologically more superficial layer (= *stratum corneum*), and others to the nerve-cells and their branches (= stratum Malpighii), and that the neuroglial cells then grow and branch all through the nerve-centre.

There seems to be no longer any reasonable doubt that the axis-cylinders of all nerve-fibres are branches (often very long) of nerve-cells. When the fibres become medullated, as in most cerebro-spinal nerve-trunks and in the white columns of the cord, the primitive cell-process becomes enveloped by a series of mesoblastic cells which give rise to the medullary and primitive sheaths, and whose boundaries are indicated by the nodes of Ranvier.

FIG. 80.



(From Balfour.) Section across Developing Spinal Cord of a Chick, on the seventh day of incubation: *pcw*, dorsal white column; *lcw*, lateral white column; *acw*, ventral white column; *c*, tissue filling up region where dorsal (posterior) fissure of the spinal cord will be formed; *pc*, posterior (dorsal) horn of gray matter; *cp*, cells lining cavity of neural canal; *agc*, anterior gray commissure; *pf*, dorsal part of spinal canal; *spc*, ventral part of spinal canal; *af*, anterior (ventral) fissure.

The white matter of the spinal cord first appears as a very thin layer, and, in the human embryo, at four places, as an anterior and a posterior white column on each side, on a level with the origin of the future anterior and posterior (= dorsal and ventral) nerve-roots.[1] It rapidly increases in thickness and covers the whole gray matter (Fig. 80). The anterior white commissure is formed very soon after the first appearance of the white matter.

The gray matter soon grows out on each side to form its anterior and posterior (ventral and dorsal) cornua. One conspicuous band of its fibres (*agc*, Fig. 80) passes across the middle line just below the neural canal, and forms the *anterior gray commissure*, through which fibres from both sides cross. There is also a well-marked dorsal extension of the gray matter along the sides of the neural canal. There is

[1] See Balfour: *Comp. Embryology*, vol. ii. p. 343.

at this stage no trace of either the anterior or posterior fissure of the spinal cord.

The anterior fissure is formed by a downgrowth, on each side of the middle line, of the anterior cornua and of the anterior white columns of the spinal cord; its commencement (*af*) is shown in Fig. 80.

The origin of the posterior (dorsal) fissure is not yet known with certainty. It is developed later than the anterior fissure, and Balfour[1] believes it to be due to an atrophy of the dorsal part of the primitive neural canal, though, as he says, "the exact mode of its formation seems to me to be still involved in some obscurity."

The spinal nerve-cells are arranged in groups answering in general to the mesoblastic somites and to the nerve-roots, so that the spinal cord, even in its adult structure, is a segmented organ. This morphological fact has no doubt important physiological consequences, but the field for research which it opens has as yet been little explored.

The Spinal Nerves.—Following Remak, most embryologists until twenty years ago believed that the peripheral nerves developed from the mesoblast, and only secondarily became connected with the central nervous system. His[2] was the first to prove by direct observation that the spinal nerves are outgrowths of the neural tube; and his observations have since been extended by many workers, so that it is now well established that all the nerves and ganglia of the body, so far as their essential nervous elements are concerned, are derived from the primitive medullary or neural tube.

[1] According to Balfour's observations on the chick embryo, the posterior fissure is formed on the seventh day of incubation. The neural canal has by this time become divided (Fig. 80) into an upper (dorsal) and lower (ventral) dilatation, separated by a narrow channel. The dilatations are known, respectively, as the posterior and anterior canals.

"Between the posterior horns of the cord the epithelium forming the root of the posterior canal is along the middle line covered by neither gray nor white matter, and on the seventh day is partially absorbed, thus transforming the canal into a wedge-shaped fissure, whose mouth, however, is seen in section to be partially closed by a triangular clump of elongated cells (Fig. 80, *c*). Below this mass of cells the fissure is open. It is separated from the 'true spinal canal' by a very narrow space, along which the side-walls have coalesced. In the lumbar and sacral regions the two still communicate."

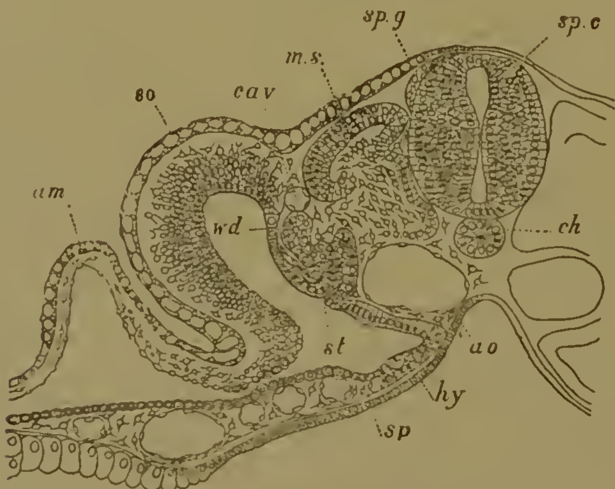
"We thus find, as was first pointed out by Lockhart Clarke, that the anterior and posterior fissures of the spinal cord are, morphologically speaking, entirely different. The anterior fissure is merely the space left between two lateral downward growths of the cord, while the posterior fissure is part of the original neural canal separated from the rest of the cavity (which goes to form the true spinal canal, *canalis centralis*) by a median coalescence of the side-walls."

"It seems to me probable, though further investigations on the point are still required, that the dorsal fissure is a direct result of the atrophy of the dorsal part of the central canal of the spinal cord."

[2] *Untersuch. üb. d. erste Anlage d. Weibelthierleibes*, 1868. See also Balfour: *Phil. Trans.*, 1876; and W. His, "Ueber d. Anfänge d. Periph. Nervensystems," *Arch. f. Anat. und Physiol.*, 1879.

The posterior roots of the spinal nerves are the first to appear in the embryo. They originate in all the higher Vertebrata from a lateral outgrowth of the epiblastic lining of the neural canal, which develops just before the closure of the tube (Fig. 81). This outgrowth (*spg*)

Fig. 81.



Cross-section of Embryonic Duck at a stage when twenty-four mesoblastic somites had developed (from Balfour and Foster): *am*, amnion; *so*, somatopleure; *sp*, splanchnopleure; *Wd*, Wolffian duct; *st*, segmental tube; *ca.v*, cardinal vein; *ms*, muscle-plate; *sp.g*, spinal ganglion; *spc*, spinal cord; *ch*, notochord; *ao*, aorta; *hy*, hypoblast.

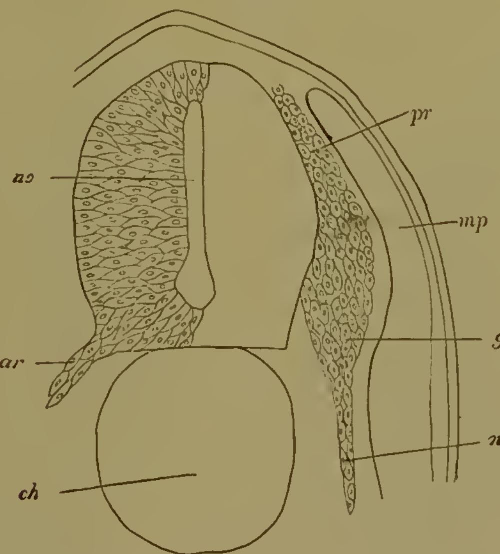
forms a ridge on each side of the neural canal extending from the region of the corpora quadrigemina to the hinder end of the spinal cord: it is named the *neural crest*. The neural crest at intervals gives origin to pear-shaped outgrowths, the commencements of the dorsal spinal roots; between these it soon disappears. Each outgrowth differentiates into a narrow proximal stalk (the *root*), a thicker part (the *ganglion*) succeeding this, and a stem (nerve) on the distal side of the ganglion (Fig. 82). The dorsal attachment of the root soon begins to shift its position: it slides from the middle line to its permanent origin at the outer side of the posterior column, and the neural crest disappears. In the rabbit the development of the posterior spinal roots commences on the ninth day.

The anterior roots arise later than the posterior as outgrowths from the wall of the neural canal (*ar*, Fig. 82). They join the posterior root beyond its ganglion. Both roots are at first cellular, and nerve-fibres (or their axis-cylinders) appear earlier in the anterior. These axis-cylinders are outgrowths from nerve-cells in the gray matter of the cord. It is possible that the keratin structures of the white fibres correspond to the horny layer of the epidermis, and are formed from the cells of the primitive roots.

The anterior roots do not originate in the same vertical plane as the posterior roots, but alternate with them: a condition which persists in the adult. Many cranial nerves (I., III., V., VII., VIII., IX., X.) arise from a neural crest similar to, and continuous with, that of the spinal cord: whether such nerves are strictly comparable, morphologically, to posterior spinal roots is as yet doubtful, and there is no doubt that some of them do not physiologically correspond to the posterior spinal roots.

The Sympathetic Nervous System was first shown by Balfour[1] to arise in certain fishes as an offshoot of the cerebro-spinal centre and its nerves. A similar origin in birds and mammals has since been discovered[2] by Schenk and Birdsell. The sympathetic ganglia appear as "swellings on the main branches of the spinal nerves some way below the ganglia."

FIG. 82.



Cross-section through Dorsal Region of a Torpedo Embryo: *pr*, posterior root of spinal nerve; *g*, spinal ganglion; *n*, prolongation of dorsal nerve-root beyond its ganglion; *ar*, anterior root of spinal nerve; *ch*, notochord; *nc*, neural canal; *mp*, muscle-plate.

Subsequently, these ganglia separate from the spinal nerve, remaining connected with it by a short branch (*ramus communicans*). The sympathetic ganglia of elasmobranchs on their first appearance are quite separate, the longitudinal commissure being a later development; but in mammals they are (at least in certain regions, as the neck) connected from the first by a commissural cord.

The Development of the Brain is so extensive a subject that only some of its main features can be here described.

When the medullary canal is formed it presents from the first an anterior (cephalic) wider portion, which is as long as, or longer than,

[1] *Monograph on Elasmobranch Fishes.*

[2] "Ueber d. Lehre von der Entwickelung d. Ganglien d. Sympatheticus," *Mith. a. d. Embryol. Instit.*, Wien, 1879.

the posterior narrower part, which ultimately develops into the spinal cord.

The cephalic portion of the neural tube next dilates so as to form (Fig. 68) an anterior, h', and posterior, h''', vesicle or dilatation. A third vesicle soon appears between the first pair at the point marked h'' in the figure. These three primary vesicles are known as the *fore-*, the *mid-*, and the *hind-brain*. Their subsequent development is essentially the same in the bird and the mammal, so that Fig. 83, which represents a chick embryo viewed from above during the second day of incubation, may be used to illustrate the condition of the cerebral vesicles of

FIG. 83.

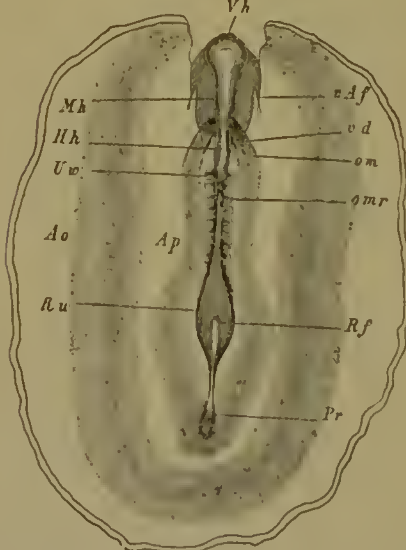


FIG. 84.

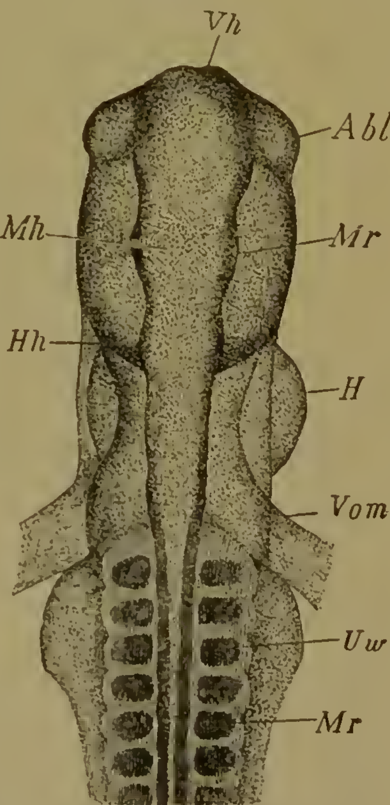


FIG. 83.—(From Kölliker.) Chick Embryo 1/6 inch (4.2 mm.) in length, viewed from above, toward the end of the second day of incubation (magnified about 19 diameters): *Ao*, vascular area; *Ap*, pellucid area; *Vh*, fore-brain; *Mh*, mid-brain; *Hh*, hind-brain.

FIG. 84.—Anterior Part of the Embryo represented in Fig. 83, more magnified: *Vh*, fore-brain; *Abl*, optic vesicles; *Mh*, mid-brain; *Mr*, its wall; *Hh*, hind-brain; *H*, heart; *Vom*, vitelline vein; *Uw*, mesoblastic somite.

the human embryo at a corresponding stage. Fig. 84 represents the anterior part of the same embryo, more magnified (40 diameters).

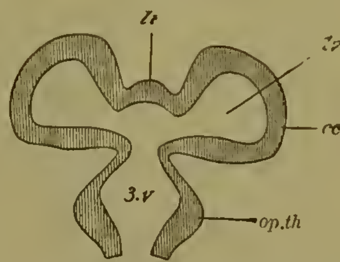
The cavity of the vesicle of the fore-brain remains in the adult mammal as the third ventricle of the brain: its front wall becomes the *lamina terminalis.*

Very early in development the fore-brain vesicle buds out on each side to form the *optic vesicles* (*Abl*, Fig. 84). These ultimately form the retinas, and their later development will be described subsequently

(p. 163). They quickly shift back, so as to become attached to the mid-brain.

Next, a median forward outgrowth from the fore-brain is developed: it divides into right and left halves, which become the cerebral hemispheres (Fig. 85). Each division contains within it an extension of the cavity of the fore-brain vesicle; these cavities remain throughout life as the lateral ventricles, and their communications with the primitive cavity of the fore-brain (third ventricle) are the foramina of Monro. The outgrowths from the fore-brain to form the cerebral hemispheres are known as the *cerebral vesicles*. From their under surfaces, near their anterior ends, olfactory lobes bud out as hollow sacs, which subsequently become solid in Mammalia. While the cerebral vesicles are forming, the hind-brain partially subdivides into a dorsal expansion (epencephalon), the rudiment of the cerebellum, and a ventral portion (metencephalon), the rudimentary medulla oblongata. The brain may at this stage be represented by the diagram, Fig. 86. Omitting the optic and olfactory vesicles, it may be described as consisting of five main divisions. The foremost of these are the paired cerebral vesicles; next comes the vesicle of the original fore-brain (I, Fig. 86); then, in order, the vesicle of the mid-brain, and the vesicle of the hind-brain with its subdivisions into cerebellar and medullary portions. The five main regions of the brain are thus mapped out early in embryonic development.

Fig. 85.



(From Foster and Balfour.) Diagrammatic Horizontal Longitudinal Section through the Fore-brain: *3.v*, third ventricle or original cavity of fore-brain; *lv*, lateral ventricle; *lt*, lamina terminalis; *ce*, rudiment of cerebral hemisphere; *op.th*, rudiment of optic thalamus.

The cells lining the vesicles give rise to the ependyma of the ventricles, to the white and gray matter of the brain, and to its neuroglia. The investing mesoblast gives origin to the blood-vessels, the pia mater, the choroid plexuses, and so forth. In some parts the epiblastic walls of the primary cavities thicken greatly; in others they remain thin, even forming throughout life a mere single layer of cells, as on the roof of the fourth ventricle of the adult brain.

The cerebral vesicles (prosencephalon) give rise by the thickening of their roofs and outer sides to the cerebral hemispheres. Their inner sides for a considerable area remain very thin, and, coming nearly in contact in the middle line, leave a space between them which is later closed in above by the corpus callosum and below by the fornix; the space thus enclosed is the *fifth ventricle* of the mammalian brain, which differs from all the others in not being a remnant of the original cavity of the medullary canal.

The multiplication and modification of the epiblast cells forming the floor of the primary cerebral vesicle give rise to the *corpus striatum.*

Fig. 86.

Diagram representing the Brain at an early stage of development: I, cavity of primary fore-brain: the thickened epiblast, *th*, on its sides will become the optic thalami; *cv*, cerebral vesicle: its lining epiblast will form the cerebral hemisphere, and its cavity remain as a lateral ventricle; *ol*, olfactory lobe; *fo*, foramen of Monro; *opt.v*, optic vesicle, still connected with the fore-brain: its lining epiblast will become the retina; *l*, thickened external epiblast, the rudiment of the lens. II, cavity of primary mid-brain (mesencephalon) becoming narrowed to form the aqueduct of Sylvius; its walls, *cr*, thicken above, below, and laterally to form the corpora quadrigemina and crura cerebri. III, cavity of primary hind-brain, subdividing to form the cerebellum (epencephalon) and medulla oblongata (metencephalon): its remnants in the adult brain form the fourth ventricle: *ce*, rudiment of cerebellum: *mo*, rudiment of medulla oblongata: *Sp*, spinal cord: *cc*, canalis centralis: *Au*, auditory pit.

The primitive fore-brain, after it has budded off the optic and cerebral vesicles, is named the diencephalon or inter-brain. It develops on its dorsal surface the pineal process and gland;[1] its sides form the optic thalami and part of the cerebral peduncles; its floor gives origin to the infundibulum,[2] part of the crura cerebri, tuber cinereum, and optic chiasma; its cavity remains as the third ventricle.

The anterior commissure in amphibia and reptiles is a complex structure, consisting of an upper portion developed from the cerebral vesicles, and representing a rudimentary corpus callosum, and a lower portion, the true anterior commissure, developed from the diencephalon, and separate in mammals from the corpus callosum (Osborn). The middle commissure is also developed from the diencephalon.

The primary mid-brain (mesencephalon) gives origin to the following parts: its roof and sides thicken to form the corpora quadrigemina; its floor and sides form the posterior parts of the crura cerebri; its cavity becomes the aqueduct of Sylvius; the posterior commissure is formed by growth of a portion of its fibres across the middle line.

[1] The so-called pineal gland, which has long been a puzzle, has lately been proved to be the remnant of a median eye which once existed on the top of the head. This eye is still present in an imperfect form in some fishes (Anguis) and reptiles (Hatteria and other lizards). The pineal body appears between the sixth and seventh weeks in the human embryo. Embryological investigation has shown that the pineal body in many existing higher vertebrates still originates as an offshoot of the optic vesicles (*vide* Haddon: *Introd. to Study of Embryology*, fig. 138, p. 163).

[2] The infundibulum subsequently becomes closely connected with the pituitary body,

The embryonic hind-brain, after separating into epencephalon and metencephalon, forms the following regions of the adult brain: the epencephalon develops into the cerebellum, the valvula cerebelli or "valve of Vieussens," the pons Varolii, and anterior peduncles of the cerebellum; its cavity remains as the anterior part of the fourth ventricle. The metencephalon (after-brain), which narrows behind and is continuous with the spinal cord, develops dorsally the ependyma lining, on its under side, the choroid plexus of the fourth ventricle; fusing with this, it forms the *tela vasculosa;* the sides and the floor of the metencephalon form the medulla oblongata or myelencephalon and the posterior peduncles of the cerebellum; its cavity remains as the posterior portion of the fourth ventricle of the brain and communicates behind with the central canal of the spinal cord.

In some of the lower vertebrates the three primary vesicles and their outgrowths remain in the same horizontal plane, so that a section including them all, such as is given in the diagram, Fig. 86, would be possible. This is not the case in higher Vertebrata: in reptiles, birds, and mammals the embryonic brain very early becomes bent in the dorso-ventral plane, so that the brain in vertical longitudinal section is S-shaped (2, Fig. 87). The first and most important bend occurs in the region of the mid-brain (*mb,* Fig. 88), just in front of the anterior end of the notochord: it is known as the *cranial flexure.*

Soon after the vesicle of the cerebral hemispheres becomes bilobed the mesoblast extends between the hemispheres; it gives origin to the *falx cerebri* and other non-nervous parts. The lateral ventricles are at first very large (Fig. 88), as are also the foramina of Monro. As development proceeds, the walls of the vesicles, at first nearly uniformly thin, thicken below and form the corpora striata, which project into the lateral ventricles, causing the cavities of these to assume a somewhat

which is usually described as a part of the brain: it is really an outgrowth from the primitive buccal cavity (stomadæum), and possibly is the remnant of an ancestral sense-organ.

"In Mammalia . . . . the part of the infundibulum which lies at the hinder end of the pituitary body is at first a simple finger-like process of the brain; but its end becomes swollen and the lumen in this part becomes obliterated. Its cells, originally similar to those of the other parts of the nervous system, and even [giving rise to] differentiated nerve-fibres, partly atrophy and partly assume an indifferent form, while at the same time there grow in between them numerous vascular and connective-tissue elements. The [part] of the infundibulum thus modified becomes inseparably connected with the true pituitary body, of which it is usually described as the posterior lobe."

"In the latter stages of development the unchanged [nervous] portion of the infundibulum becomes gradually prolonged and forms an elongated diverticulum of the [floor of the] third ventricle, the apex of which is in contact with the pituitary body."

"The posterior part of the primitive infundibulum becomes the corpus albicans, which is double in man and the higher apes; the ventral part of the posterior wall forms the tuber cinereum" (Foster and Balfour: *Embryol.*, p. 372).

semilunar shape.[1] The horns of these demilunes become the ascending and descending cornua of the lateral ventricles of the adult brain.

The corpora striata are from the first continuous posteriorly with the optic thalami. As they develop, the surfaces of contact become so extensive that the original sharp demarcation between the cerebral vesicles and the thalamencephalon is obscured.

The outer walls of the cerebral vesicles (or, as we may now name them, the cerebral hemispheres) thicken; their inner walls remain

Fig. 87.

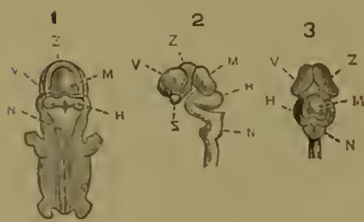


Fig. 88.

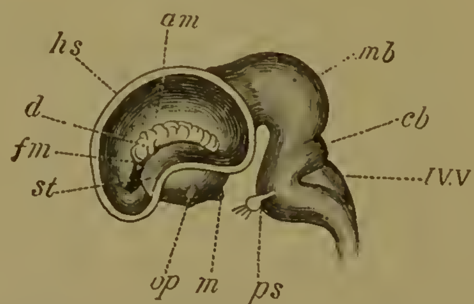


Fig. 87.—(From Kölliker.) Central Nervous System of a Seven Weeks' Human Embryo: 1, from dorsal side, with brain and spinal cord exposed; 2, lateral view of brain and upper part of spinal cord; 3, dorsal view of brain: V, cerebral vesicle; Z, diencephalon; M, mid-brain: H, epencephalon; N, metencephalon; X′, ventral anterior end of diencephalon where tuber cinereum will develop.

Fig. 88.—(After Mihalkovics.) Lateral View of Brain of Calf Embryo, 5 cm. long. The outer wall of the hemisphere is removed, so as to give a view of the interior of the left lateral ventricle: *hs*, cut wall of the hemisphere; *st*, corpus striatum; *am*, hippocampus major; *d*, choroid plexus of lateral ventricle; *fm*, foramen of Monro; *op*, optic tract; *m*, infundibulum; *mb*, mid-brain; *cb*, cerebellum; *IV.V*, roof of fourth ventricle; *ps*, pons Varolii, close to which is the fifth nerve with the Gasserian ganglion.

thinner, but give rise to two folds which project into the lateral ventricle. These folds extend from the foramen of Monro along nearly the whole length of the descending cornu. The upper (dorsal) one forms the hippocampus major.

"The wall of the lower fold becomes very thin, and a vascular plexus derived from the connective tissue [mesoblastic] septum between the hemispheres is formed outside it." The fold next projects into the cavity of the lateral ventricle, and with its mesoblastic lining forms the choroid plexus.

The inner, or median, thin walls of the cerebral hemispheres come in contact, and to a great extent fuse across the middle line and form the *septum lucidum*. In man a cavity (part of the original space between the cerebral vesicles) persists in this septum, and is known as the fifth ventricle of the brain. In the lower part of the septum lucidum transverse fibres form the true anterior commissure. In its upper part are next developed the vertical fibres of the *fornix;* these diverge behind as the *posterior pillars*, and enter the cornu ammonis. "Ven-

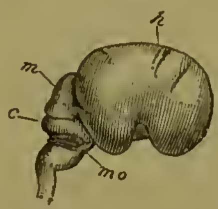
[1] Balfour: *Comp. Embryol.*, vol. ii. p. 362.

trally, they are continued, as the descending or anterior pillars of the fornix, into the corpus albicans, and thence into the optic thalamus."

The corpus callosum develops later: it begins in the upper part of the septum lucidum, and at first only its front portion (genu, rostrum) is formed. This portion only is found in the lower mammals; in the higher, the posterior portion is gradually developed as the cerebral hemispheres grow backward.

The cerebral hemispheres of the human embryo are at first smooth on the surface, and do not cover (V, Fig. 87) the thalamencephalon. Extending backward, they overlap the optic thalami (Figs. 89 *et seq.*) during the second and third months of intra-uterine life. During the fifth month the backward extension of the hemispheres covers most of the mid-brain, and during the sixth month the latter is completely overlapped by them. Later still, the cerebellum is similarly completely concealed from above.

FIG. 89.



(From Kölliker.) Brain of Three Months' Human Embryo, natural size: *h*, right cerebral hemisphere: all its lobes and the fissure of Sylvius are distinguishable; *m*, mid-brain; *c*, cerebellum; *mo*, remnant of membrana obturatorii ventriculi, IV, prolonged from cerebellum over medulla.

FIG. 90.

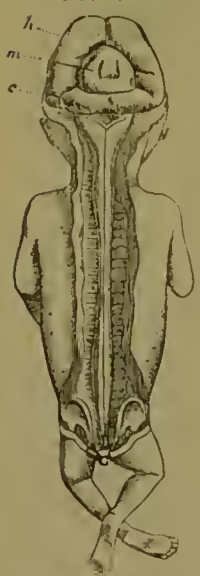


FIG. 91.

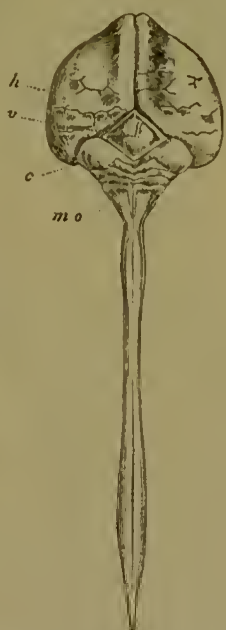


FIG. 92.

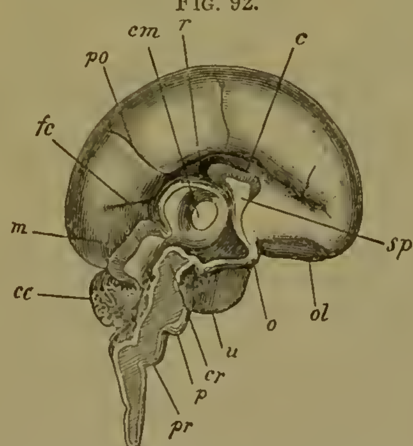


FIG. 90.—(From Kölliker.) Human Embryo of Three Months, natural size (the brain and spinal cord exposed): *h*, cerebral hemisphere; *m*, mid-brain; *c*, cerebellum: behind the latter are seen the medulla oblongata and the spinal cord, the latter reaching to the tip of the coccyx.

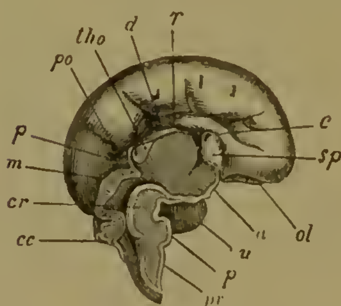
FIG. 91.—(From Kölliker.) Brain and Spinal Cord of Four Months' Human Embryo, natural size: *h*, cerebral hemispheres; *v*, corpora quadrigemina (mid-brain), partly overlapped by cerebral hemispheres; *c*, cerebellum: its apparently hindmost fold is only the membrana obturatoria; *mo*, medulla oblongata.

FIG. 92.—Brain of Human Embryo of the Fifth Month, natural size (from Kölliker): *pr*, pyramids; *p*, pons; *cr*, crus cerebri; *u*, temporal lobe; *o*, optic chiasm; *ol*, olfactory lobe; *sp*, septum lucidum; *c*, corpus callosum; *cm*, soft commissure; *po*, parieto-occipital fissure; *fc*, calcarine fissure; *m*, mid-brain; *cc*, cerebellum.

The fissures of the cerebral hemispheres have from their mode of origin been divided by Kölliker into primary and secondary: the primary fissures are due to infoldings of the whole thickness of the thin walls of the cerebral vesicles at an early stage of development; the secondary are due to later superficial outgrowths (convolutions of the surface of the hemisphere). His distinguishes them as "total" and "cortical" fissures respectively. The primary fissures (Figs. 91 and 93) appear during the third month, are most marked in the fourth, and for the most part disappear during the fifth, so that during the sixth month the outer cerebral surface is again almost quite smooth (Fig. 94). They

FIG. 94.

FIG. 93.



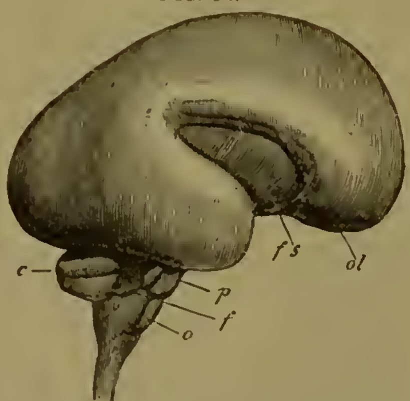


FIG. 93.—Brain of Four Months' Human Embryo, natural size (from Kölliker): *pr*, pyramids; *p*, pons; *cr*, crus cerebri; *o*, floor of third ventricle in region of optic chiasma; *a*, temporal lobe; *ol*, olfactory lobe; *sp*, septum lucidum; *c*, corpus callosum; *po*, occipito-parietal sulcus; *r*, pineal gland; *m*, mid-brain; *cc*, cerebellum.

FIG. 94.—Brain of Six Months' Human Embryo, natural size (from Kölliker): *ol*, olfactory lobe; *fs*, fissure of Sylvius; *c*, cerebellum; *p*, pons Varolii; *f*, flocculus; *o*, olivary body.

appear to be due to a more rapid growth for a time of the cerebral hemispheres than of the cranial cavity, so that the former have to become folded in order to gain room.

Certain of these primary fissures are, however, permanent—namely, the *sulcus hippocampus*; the *sulcus parieto-occipitalis* (Fig. 93, *po*); the *sulcus calcarinus* (Fig. 92, *fc*); the infolding (p. 160) of the ependyma to cover the choroid plexuses. The *Sylvian fissure* may perhaps be classed with the permanent primary fissures, though it differs from the others in some important respects.[1] It is conspicuous in three-month human embryos (Fig. 89) as a small depression on the under side of the expanding cerebral vesicles. It corresponds in position to the internal region in which the corpus striatum will form; and it seems as if in this region the wall of the cerebral vesicle chiefly thickens on its inner and elsewhere on its outer side. Hence the fissure is not due to a true infolding of the wall of the vesicle, but is a mere valley left on the exterior by excessive superficial thickening of the parts surrounding it.

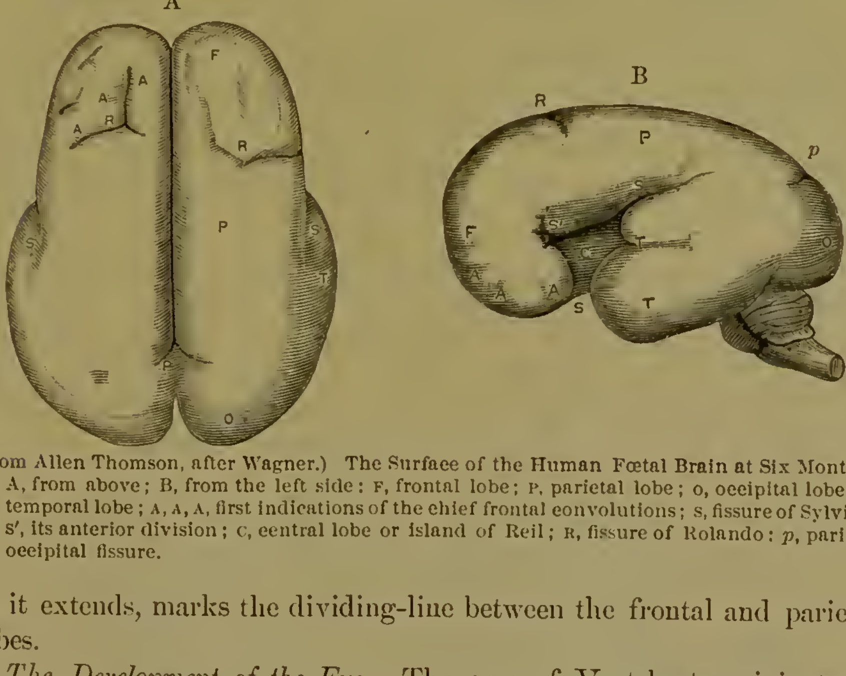
[1] Kölliker: *Entwicklungsgeschichte*, vol. ii. p. 558.

Its external form at this time corresponds to that of the corpus striatum (Fig. 94). The convolutions of the island of Reil only become distinct toward the end of fœtal life.

The Sylvian fissure marks off with tolerable distinctness the frontal from the temporal lobes; these, with the olfactory lobes, are the only well-marked primary subdivisions of the human cerebral hemispheres. The parieto-occipital fissure, which appears almost contemporaneously with the Sylvian, imperfectly marks off the occipital lobe (Fig. 92).

The secondary fissures appear toward the end of the fifth and during the sixth month. They have been especially studied by Ecker,[1] to whose description the reader is referred. The secondary sulci appear about the beginning of the sixth month or the end of the fifth. The first is the central sulcus or fissure of Rolando (Fig. 95), which, so far

FIG. 95.



(From Allen Thomson, after Wagner.) The Surface of the Human Fœtal Brain at Six Months: A, from above; B, from the left side: F, frontal lobe; P, parietal lobe; O, occipital lobe; T, temporal lobe; A, A, A, first indications of the chief frontal convolutions; S, fissure of Sylvius; S′, its anterior division; C, central lobe or island of Reil; R, fissure of Rolando: *p*, parieto-occipital fissure.

as it extends, marks the dividing-line between the frontal and parietal lobes.

The Development of the Eye.—The eyes of Vertebrata originate as outgrowths (Fig. 84) from the fore-brain. These outgrowths appear in mammals even before the vesicles of the fore-brain are closed (Fig. 96). They are represented somewhat later in the diagram (Fig. 86), at a stage when the connection of their cavities with the fore-brain cavity has become narrowed. The narrowed stem is the *optic stalk;* the vesicle on its end is the *primary optic vesicle.* As the embryo develops the epiblast lining the primary optic vesicle comes nearly into contact

[1] *Icones physiologicæ*, Leipzig, 1851–59; and *Arch. für Anthrop.*, 1868. The following may also be consulted: Kölliker, *Entwicklungsgeschichte*, Leipzig, 1879, p. 563 *et seq.;* Pansch, *Archiv f. Anthrop.*, 1868; Mihalkovics, *Entwick. d. Gehirns.*, 1877.

with the external epiblast; but in mammals a layer of mesoblast always separates them (Fig. 86). The external epiblast (*l*, Fig. 86) covering the most projecting part of the primary optic vesicle thickens, and then

FIG. 96.

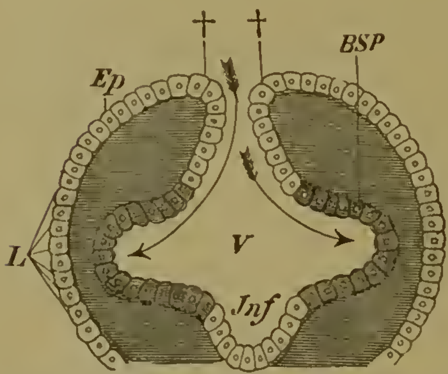


FIG. 97.

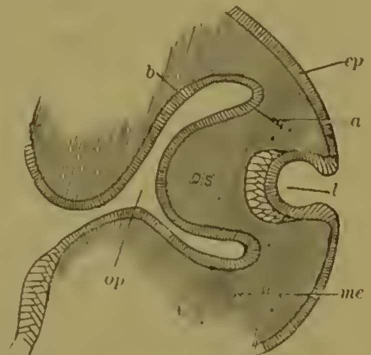
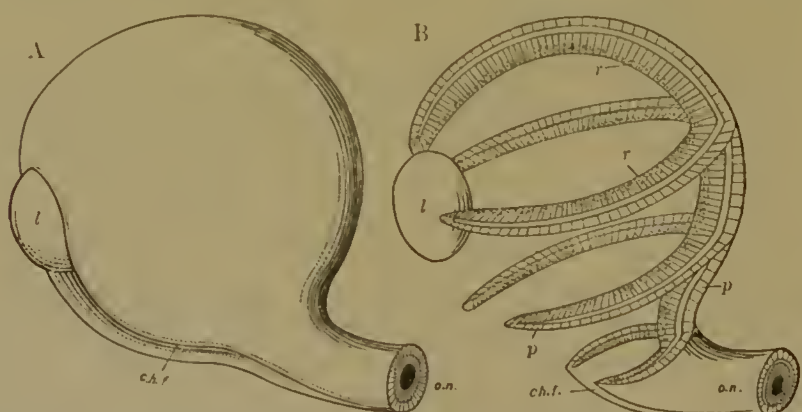


FIG. 96.—(After Wiedersheim.) *Ep*, epiblast, invaginated at † to line medullary groove; V, cavity of fore-brain (third ventricle); BSP, cells of optic vesicle; *Inf*, commencement of infundibulum; L, epiblast cells from which the lens is developed later.

FIG. 97.—Diagram: *op*, cavity of primary optic vesicle, nearly obliterated by the infolding of its epiblast to form the optic cup; *os*, cavity of optic cup; *b*, epiblast of posterior half of primary optic vesicle which will form the pigmentary layer of the retina; *a*, involuted epiblast of anterior half of primary optic vesicle: it gives origin to most of the retina; *l*, commencement of the lens; *me*, mesoblast; *ep*, external epiblast.

the primary optic vesicle doubles back on itself (Fig. 97), so as to nearly obliterate its original cavity, *op*, and form a new one, the second-

FIG. 98.

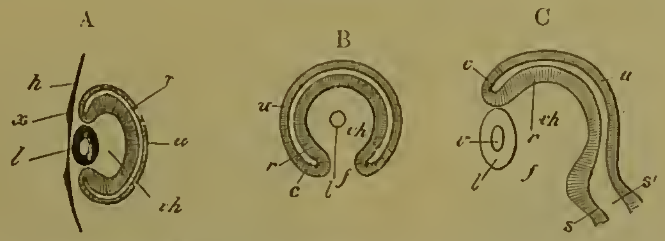


(From Haddon.) Diagrams Illustrating the Formation of the Optic Cup and Choroidal Fissure; A, lateral view of the optic vesicle; B, skeletal view, the greater portion of the optic cup being supposed to be cut away; *ch.f*, chorodial fissure; *l*, lens; *o.n.* optic nerve; *p*, pigmentary layer of retina; *r*, cells which will form the retina inside the pigmentary layer.

ary optic vesicle, *os*, known as the *optic cup*. This cup has an outer, *a*, and an inner, *b*, wall of epiblast cells. These layers subsequently come into contact and completely obliterate the cavity of the primary optic vesicle. The outer gives rise to the pigmentary layer of the retina, the inner to the remainder of that organ.

When the primary optic vesicle pits-in to form the optic cup, its involution occurs not only from without in, but also from below up (Fig. 98). Sections of the secondary optic vesicle at this stage therefore differ much in appearance when cut in different planes: this is illustrated in Fig. 99. A horizontal section through the the embryonic eye

Fig. 99.



A, Horizontal Section through Secondary Optic Vesicle; B, cross-section through the same; C, vertical section passing through the choroidal fissure: *vh*, cavity of secondary optic vesicle: the mesoblast extends into it and forms later the vitreous humor; *f*, choroidal fissure; *h*, superficial epiblast; *x*, its thickening over the surface of the optic vesicle; *l*, portion of thickened external epiblast which has been separated to form the lens, which latter is still a hollow vesicle; *s*, inner, *s'*, outer layer of optic cup.

is represented at *A*, a vertical transverse section at *B*, and a vertical longitudinal section at *C*.

The cavity of the secondary optic vesicle is, as shown in Fig. 97, filled from the first with mesoblast. The infolding of the primary vesicle extends to the optic stalk, which consequently forms a double-layered epiblastic tube open on its under side (Fig. 100, A). Mesoblast

Fig. 100.

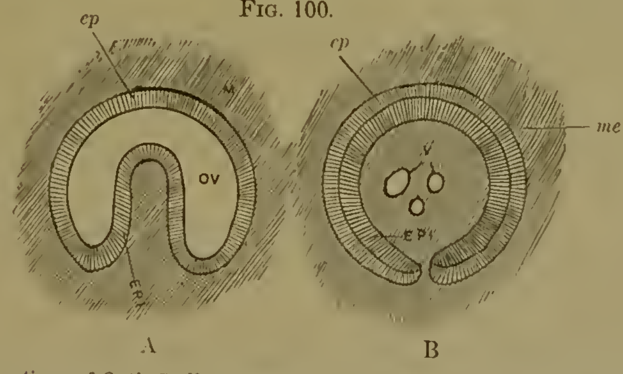


Diagram. Cross-sections of Optic Stalk: *A*, before its epiblastic layers have come in contact; *B*, after they have met, and the mesoblast, shut in by their infolding, has given origin to the central artery and other blood-vessels and the connective tissues surrounding them; *cp*, epiblast of outer layer of optic stalk; *cp'*, epiblast of infolded layer; *me*, mesoblast; *v*, developing blood-vessels of optic nerve; *ov*, remnant of primitive cavity of the optic stalk.

extends into its cavity and forms the central artery of the retina and other vessels, and their enveloping connective tissue. The sides of the stalk soon unite below (Fig. 100, B). As development proceeds, the optic stalk shifts back, so as to become attached to the optic chiasma. Its primitive cells form the neuroglia of the permanent optic nerves, the true optic nerve-fibres being a secondary development. Whether they arise from cells of the optic vesicle or as branches of cells in the mid-brain is not yet certain.

The first indication of the lens is a thickening of the epiblast covering the most projecting portion of the primary optic vesicle (Fig. 86, *l*). This thickening soon becomes hollow, and forms a pit (Fig. 101) com-

FIG. 101.

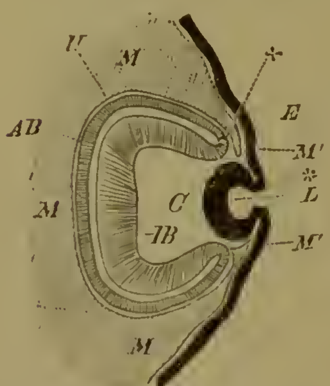


FIG. 102.

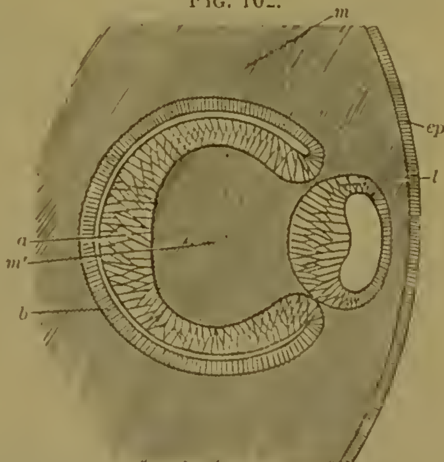


FIG. 101.—(From Wiedersheim.) Semi-diagrammatic Figure of the Secondary Optic Vesicle and of the Developing Lens: *IB*, layer of secondary optic vesicle which gives origin to most of the retina; *AB*, layer of secondary optic vesicle which gives origin to the pigmentary retinal layer; † indicates the place at which the primary optic vesicle has been doubled back on itself, *H*, remnant of cavity of primary optic vesicle; *L*, lens, as a cup open on the exterior; *, point of invagination of outer epiblast to form lens; *M*, mesoblast; *M'*, point from which mesoblast grows in to form iris and body of cornea; *C*, posterior chamber of eye, which becomes filled with mesoblast that ultimately forms the vitreous humor.

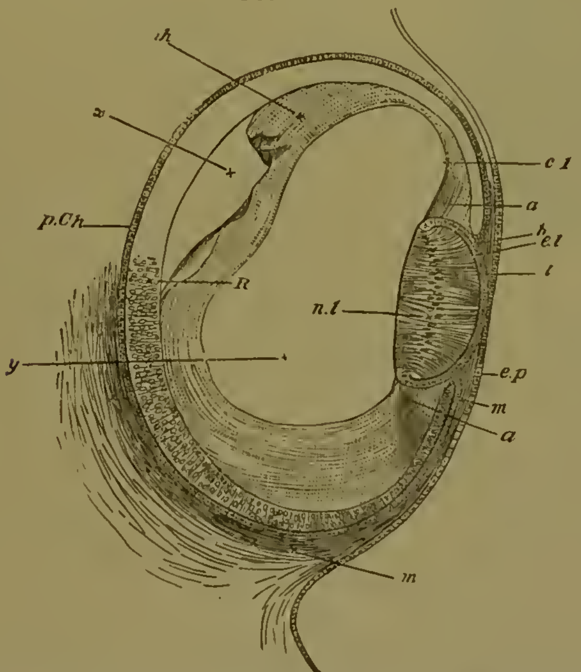
FIG. 102.—The Developing Eye in Horizontal Section at a stage soon after the lens has separated from the external epiblast (diagrammatic): *m*, mesoblast; *mi*, mesoblast included in secondary optic vesicle, the rudiment of the vitreous humor; *b*, outer layer of optic cup, which develops into the pigmentary retinal layer; *a*, inner layer of optic cup, which forms most of the retina between *b* and *a* is seen the remnant of the cavity of the primary optic vesicle; *ep*, external epiblast; *l*, rudiment of lens, separated from external epiblast, but still hollow, though its posterior wall has commenced to thicken and encroach on its cavity.

municating by a narrow aperture with the exterior. The mouth of the pit closes, and the epiblastic cavity thus formed (*l*, Fig. 99, A) separates from the rest of the outer epiblast (Fig. 102). The cells on the deeper side of the lens-cavity multiply rapidly, and form a thick layer, convex toward the surface of the head. They thus gradually obliterate the primitive cavity of the lens, and ultimately come into contact (Fig. 103) with the cells of the more superficial side. The deeper cells have by this time grown into nucleated fibres; the superficial cells form the epithelium covering the front of the embryonic lens. The lens capsule is probably a mere excretionary layer deposited by the cells which form the organ.

While the developmental changes described above are taking place the mesoblast surrounding the optic cup gives origin to the choroid and sclerotic, the ciliary muscle and ligamentum pectinatum, to most of the iris and of the ciliary processes. The anterior margin of the optic cup forms the *pars ciliaris* of the retina.

The Choroidal Fissure (Fig. 98) is the opening through which the mesoblast enters, from below, the cavity of the secondary optic vesicle;

FIG. 103.



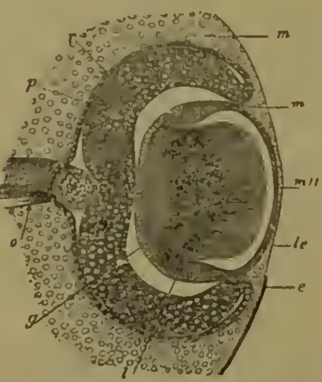
(From Balfour.) Section of Eye of Chick on the Fourth Day of Incubation: *c.p*, superficial epiblast of the side of the head; *R*, inner layer of optic cup; *p.Ch*, outer (pigmentary) layer of optic cup; *l*, lens, its cavity now quite obliterated, and its anterior cells remaining as a mere epithelial stratum, *el*; *m*, mesoblast surrounding optic cup, and about to form the choroid and sclerotic; *y*, commencement of vitreous humor.

it sometimes remains unclosed during life, giving rise to the condition known as *coloboma*.

The *vitreous humor* is formed by mesoblast which enters the secondary optic vesicle through the choroidal fissure.

The *cornea* is developed partly (conjunctival epithelium) from the epiblast left on the surface (*cp*, Fig. 102) when the lens is separated, and partly (body of cornea) from the mesoblast which grows in between this epiblast and the lens. This mesoblast (Fig. 104) is at first adherent to the outer surface of the lens and the inner surface of the corneal conjunctiva. It soon becomes cleft into an inner (iris) and outer (body of cornea) stratum. The cavity between these layers becomes the chamber of the aqueous humor, but is not dilated by liquid until near the normal time of birth. The epithelium on the back of the iris is an outgrowth from the epiblast of the lens: the membrane of Descemet is formed by flattening of mesoblast cells on the inner side of the cornea. The iris at first completely covers the front of the lens, this portion of it being known as the *pupillary membrane.* In the human race this membrane is normally absorbed before birth.

Fig. 104.



Horizontal Section through the Eye of a Rabbit Embryo of Fourteen Days (from Kölliker; magnified about 62 diameters): *o*, optic nerve; *p*, pigmentary layer of retina; *r*, inner layer of retina; *m*, mesoblast surrounding secondary optic vesicle; *m''*, mesoblast in front of lens; *l*, lens; *le*, its anterior wall, formed of flattened cells; *e*, external epiblast, which is only represented in the lower part of the figure.

The Development of the Ear.—The first indications of the ears are two pits (*Au*, Fig. 86) on the sides of the hind-brain. The mouths of these pits close very soon, and thus a pair of cavities lined by epiblast cells come to be buried in the mesoblast of the developing skull. The lining cells of these cavities become the epithelial structures and their derivatives (*e. g.* rods of Corti) of the labyrinth: the mesoblast immediately surrounding them gives origin to the remainder of the membranous internal ear; a cleft in it becomes the perilymph cavity, and on the outside of this it ossifies to form the bony internal ear. The tympanic cavity and membrane and the Eustachian tube are later developments from the first visceral cleft (p. 184).

The Development of the Vascular System.—"It seems probable—mainly, it must be admitted, on *a priori* grounds—that the [blood-] vascular and lymphatic systems have originated from the conversion of indefinite spaces, primitively situated in the general connective tissue, into definite channels. It is quite certain that vascular systems have arisen independently in many types." . . . . "On the whole, it would seem probable that the vascular system has in most cases arisen independently of the body-cavity [cœlome]. . . . . As pointed out by the Hertwigs, a vascular system is always absent where there is not a considerable development of connective tissue."[1]

The smaller blood-vessels often arise by a hollowing of the bodies and communicating branches of mesoblast cells. The superficial protoplasm and some of the multiplying nuclei of these cells form the walls of the primitive blood-vessels; and in mammals the first blood-corpuscles are formed by a budding-off of nuclei, surrounded by some cell-protoplasm from the interior of the primary blood-channels. The blood and blood-vessels of the higher vertebrates are first developed in

[1] Balfour: *Comp. Embryol.*, vol. ii. p. 519.

that portion of the somatopleure which forms the proximal part of the yelk-sac (Fig. 55, *av*) and is known as the *vascular area* (p. 128).

The larger trunks have been shown to commence in some invertebrates as solid cords of cells; the central cells become corpuscles, and

FIG. 105.

Part of a Network of Developing Blood-vessels from the Vascular Area of a Guinea-pig (from Schäfer): *bl*, blood-corpuscles becoming free in an enlarged and hollowed part of a network of mesoblast cells. The smaller figure, to the left, represents *a* of the larger figure more magnified; *d*, a dividing nucleus.

the peripheral form the coats of the vessel. This mode of origin has not yet been proved to occur in vertebrates: the main arteries and veins possibly arise as mere clefts, the lining cells of which subsequently become modified to form the vascular walls.

The Development of the Heart.—The mammalian heart commences as a pair of tubular clefts in the mesoblast of the head region of the embryo. These tubes (*a*, Fig. 106) lie at first on the sides of that part

FIG. 106.

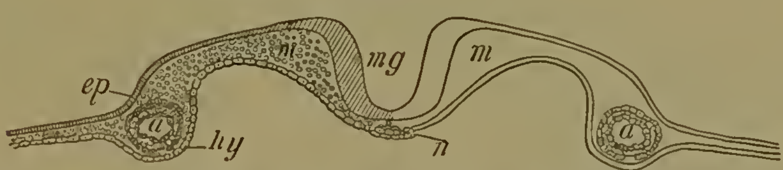


Diagram: *a*, cavity of primitive heart surrounded by an inner (endothelial) and outer (muscular) layer of mesoblast cells: the cells of these layers are united by branches; *hy*, hypoblast; *ep*, epiblast; *m*, mesoblast; *mg*, medullary groove; *n*, thickening of hypoblast to form the commencement of the notochord.

of the medullary groove which will ultimately form the hind- and mid-brains. They appear before the medullary groove has closed and while the blastoderm has not been folded in to enclose the pharyngeal cavity on the ventral side. The head-fold (p. 112) has not yet arisen, its appearance in Mammalia being comparatively late. As the blastoderm tucks-in from each side to mark off the under surface of the head-fold and enclose the pharynx, the paired hearts are brought nearer together (Fig. 107). Next (Fig. 108) they come into almost immediate contact in the middle line, beneath the anterior part of the ali-

Fig. 107.

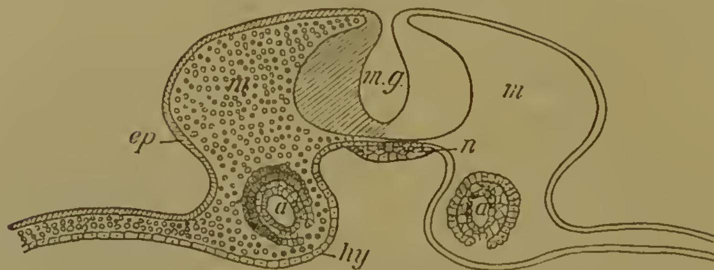


Diagram. The letters of reference are as in Fig. 106.

mentary canal. Meanwhile, the forward growth of the head and the increasing tucking-in from before backward of the under curve (Fig. 40) of the head-fold, shift the heart backward in relation to the brain so that it comes to lie under the mid-brain (Fig. 109). At this time the pleuroperitoneal cavity has appeared: its anterior portion divides into right and left extensions, and these branches, growing forward, partially enclose (*pp*, Figs. 108, 109) the developing

Fig. 108.

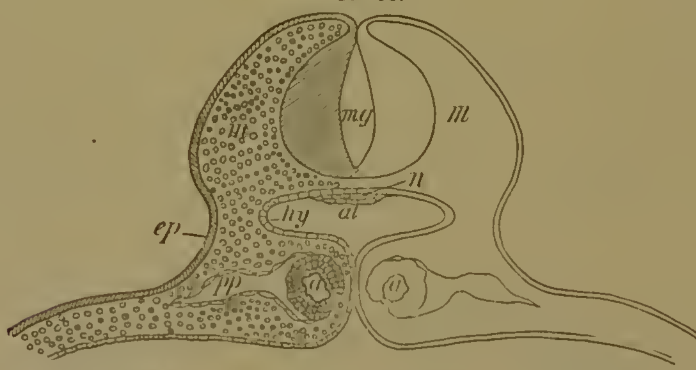
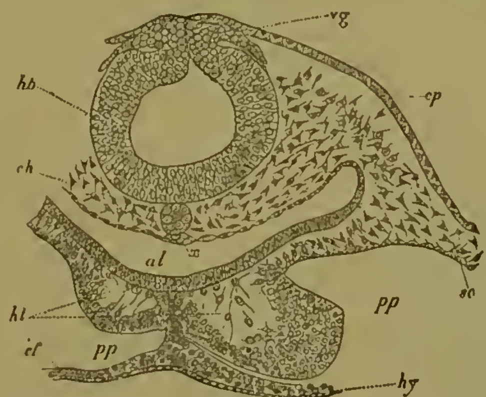


Diagram: *pp*, anterior extension of pleuroperitoneal cavity; *al*, pharynx: the other letters of reference are as in Fig. 106.

heart. From them the pericardiac cavity is afterward formed. Later still, as the neck develops, the heart is shifted farther back in relation to the brain; it lies in the anterior part of the pleuroperitoneal cavity, attached to the under side of the alimentary tube, and in a position just above the letters *pp* in Fig. 40. Immediately in front of it is the uncleft mesoblast of the neck, which, as has already been stated, never cleaves into somatic and splanchnopleuric layers.

Soon after the first appearance of the primary cardiac cavities the cells immediately surrounding them (Fig. 106) form a special layer, which is the beginning of the endothelium of the heart. Cells external to this also differentiate and multiply (Figs. 106, 107, 108); they ultimately form the myocardium. A space exists for some time (Figs. 106, 107) between the cardiac endothelium and the primitive myocardium; but it is traversed by branches from the cells of these two lay-

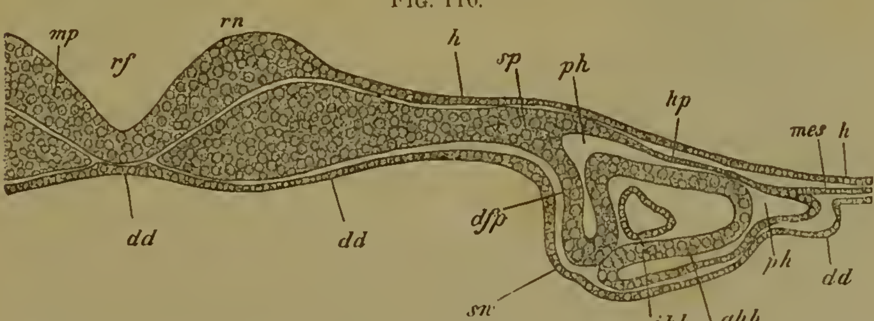
FIG. 109.



(From Balfour.) Transverse Section through Posterior Part of the Head of a Chick after thirty hours' incubation. On account of the relatively later formation of the head-fold in mammals, the relation of parts exhibited in the section answers to a later stage of mammalian as compared with avian development. *hb*, hind-brain; *vg*, origin of pneumogastric nerve; *ch*, notochord; *al*, pharynx; *ht*, heart; *pp*, pleuroperitoneal cavity; *so*, somatic layer of meso blast; *st*, splanchnic layer of mesoblast; *hy*, hypoblast.

ers, or, more probably, is occupied by branched mesoblastic cells which develop later into the connective-tissue stratum of the endocardium. In Fig. 110 this stage is represented, though the figure is defective,

FIG. 110.

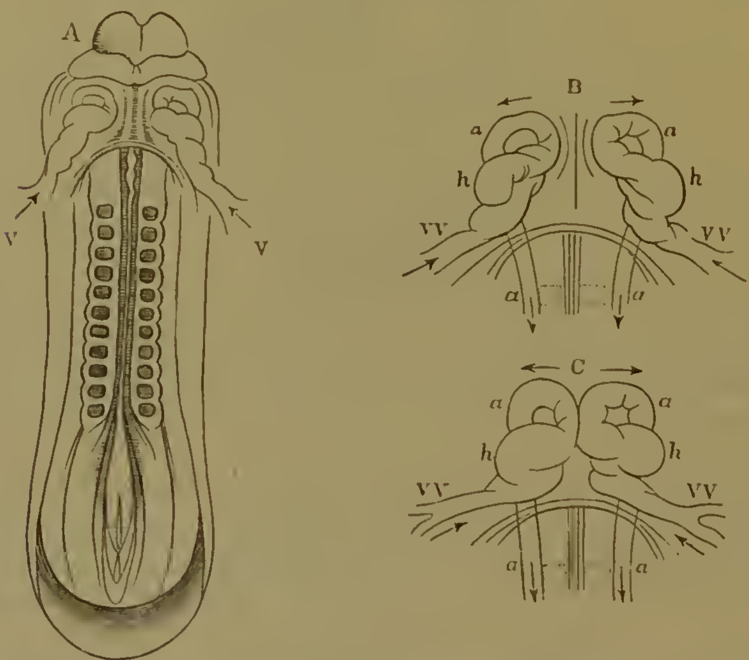


(From Kölliker.) Part of Cross-section through Head Region of a Rabbit Embryo of eight days and fourteen hours: *rf*, medullary groove; *mp*, epiblast of medullary groove; *h*, external epiblast; *hp*, somatic layer of mesoblast; *dfp*, splanchnic layer of mesoblast, continuous with the myocardium, *ahh; ihh*, cardiac endothelium; *ph*, front end of pleuroperitoneal cavity; *mes*, uncleft mesoblast, external to the heart; *sw*, wall of developing pharynx; *dd*, developing notochord.

inasmuch as it does not indicate the stratum lying between and uniting the endocardium and myocardium.

The primary mammalian hearts are at first simple straight tubes. Each receives at its posterior extremity a vitelline vein, and pumps out blood anteriorly into the aorta. The aortæ pass forward into the neck mesoblast, and there turn dorsally: near the notochord they curve backward and run side by side toward the posterior end of the embryo. The hearts quickly become curved, and also exhibit (Fig. 111) dilatations at intervals; the most posterior dilatations, into which the vitelline veins, VV, open, are the rudiments of the auricles; these are succeeded by (*h*) swellings which indicate the commencing ventricles.

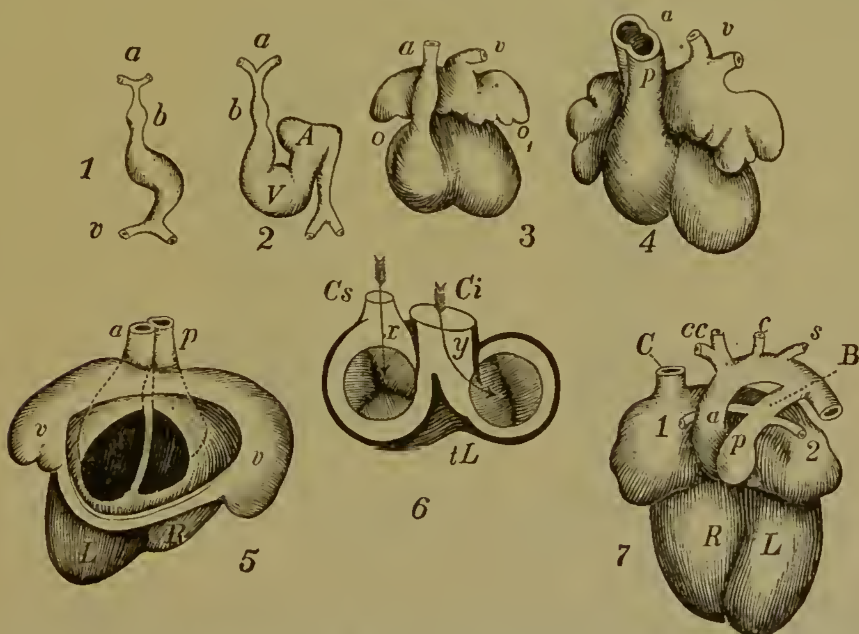
Fig. 111.



Embryo Rabbit of nine days and three hours, showing the commencing heart in two stages (after Allen Thomson; magnified 22 diameters): A, ventral view of the embryo, whose heart is represented in more detail in B; C, diagram of the heart of a slightly older rabbit embryo, in which the two halves of the heart have come into contact and commenced to coalesce; *h*, rudiment of the ventricle; *a*, primitive aortic arch and descending aorta; VV, vitelline veins entering the heart from behind. The arrows indicate the course of the blood.

The two hearts next meet and fuse in the middle line, and their cavities become continuous by absorption of the partition-walls. Fig. 112, 1, illustrates the structure of the organ at this stage. The single median tubular heart is now fixed anteriorly by its arterial and posteriorly by its venous connection, and exhibits a dilatation, *b*, where the aortæ arise from it; this dilatation is the *aortic bulb*. The vitelline veins have also joined one another near the heart to form the *venous sinus*. The middle part of the heart becomes free and bulges out on the under side of the throat (Fig. 113), and the whole organ becomes somewhat horseshoe-shaped. As this change in form occurs, the primitive posterior or venous end of the heart becomes pushed dorsally (A, 2, Fig. 112), in reference to the ventricular portion, V: from it the auricles (3, 4, Fig. 112) grow out on each side. About the fourth or fifth week in the human embryo the septum between the ventricles commences to develop (5, Fig. 112). A little later the portion of the aortic bulb nearest the ventricles becomes divided by a cross-septum which ultimately fuses with the ventricular partition; it separates the root of the pulmonary artery from the aorta, but until after birth the two vessels meet at a short distance from the heart (B, Fig. 112, 7). The auricular septum appears later (eighth week) than the ventricular, and remains incomplete until after birth, so as to allow the two auricles to communicate through the *foramen ovale.* The venous sinus has mean-

Fig. 112.

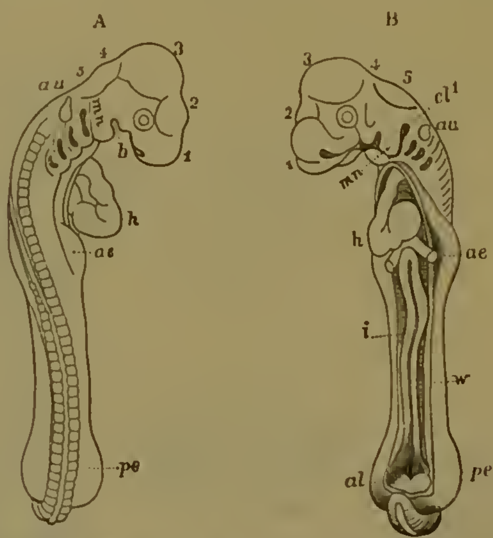


To Illustrate the Development of the Heart (after Landois): 1, heart after its two primitive tubes have coalesced; *b*, aortic bulb; *a*, first pair of aortic arches; *v*, venous end of heart; 2, heart curved so as to resemble a horseshoe; *a* and *b*, as before; *A*, commencing auricles; on these the commencing auricular appendages, *o* and *o'*, are shown; *V*, commencing ventricles: 4 shows the commencing division of the aortic bulb into aorta and pulmonary artery; 5 shows the embryonic heart after the dorsal auricular wall has been cut away, so as to expose the cavities of the ventricles and the septum which has developed between them; 6 indicates the direction of the venous blood, from the superior cava, *Cs*, into the right ventricle, and from the inferior cava, *Ci*, into the left auricle; 7, heart of fœtus at term; *R*, right, *L*, left ventricle; *a*, aorta and (*cc*, *c*, *s*) the branches from its arch; *B*, ductus arteriosus (*ductus Botalli*); *p*, pulmonary artery, and 1 and 2, its small branches to the lungs.

while largely been absorbed into the developing auricles, and what remains of it forms, close to the heart, three large vessels—the inferior and a right and left superior vena cava (p. 178). The inferior cava opens into the auricle on the right side of the septum, close behind the foramen ovale; about the eleventh week the Eustachian valve appears on the right side of its orifice, lying between it and the aperture of the left superior cava (=*coronary sinus* of the adult). This valve is so placed as to aid in directing blood from the inferior cava into the left auricle, and blood from the upper cavæ into the right ventricle.

The primitive auricular septum springs from the ventral side of the auricular cavity, and falls short of reaching the dorsal side, so as to leave the foramen ovale open. About the eleventh week another auricular septum springs from the dorsal side, extends ventrally, and overlaps the primary septum, lying on its left side. It never becomes large, and until after the middle of fœtal life does not even become wide

FIG. 113.



(From Allen Thomson, after His.) Outlines of Chick Embryo at the end of the third day of incubation: A, dorsal and right sides; B, ventral and left sides; 1 to 5, vesicles of the brain; *b*, mouth; *mn*, inferior maxillary plate: behind it are the four visceral clefts; *ae*, rudiment of fore limb; *pe*, rudiment of hind limb; *au*, auditory pit; *h*, heart.

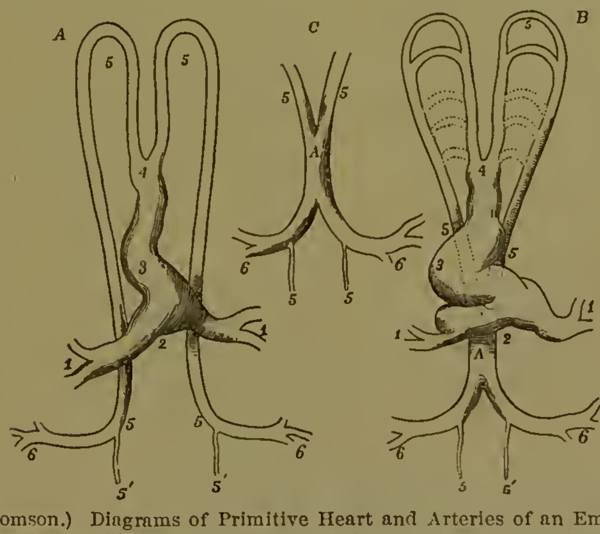
enough to cover the whole foramen ovale, over which it hangs like a curtain. In the later months of intra-uterine life it hangs beyond the aperture of the foramen, and forms a sort of valve: pressure on its right will separate it from the proper auricular septum and open the foramen ovale, while pressure on its left side will have the contrary effect. In the days immediately succeeding birth it gradually adheres to the auricular septum, and closes the aperture of communication between the auricles.[1]

Development of the Arteries.—The aortic bulb, passing forward (after the two halves of the heart have fused in the middle line to form a single tube, and the whole organ has shifted back to the position on the under side of the somatopleure and just above the letters *pp* in Fig. 40), enters the uncleft mesoblast of the developing neck. Here it gives rise to the first pair of aortic arches: these turn dorsally on the sides of the

[1] For a good account of the structure and development of the auricular septum see Henle, *Anatomie des Menschen*, vol. ii.

throat, and when they reach the region of the notochord turn backward and run as a pair of *dorsal aortæ* toward the tail end of the embryo (*A*, Fig. 114). The two dorsal aortæ are shown in cross-section in several preceding figures (67 and 69): they soon meet behind the heart and fuse into a single tube (*B*, Fig. 114), the permanent dorsal aorta. At first the main branches of the aorta are the vitelline arteries (6), which carry blood to the vascular area of the yelk-sac, and beyond the origin of these branches they are much reduced (5′) in size. Most of the blood thus goes at first to the umbilical vesicle, from which it is returned to the heart by the vitelline veins. As the umbilical vesicle rapidly diminishes, less and less blood is sent to it, and the vitelline arteries become insignificant. The parts of the aortæ behind them become larger and convey more

Fig. 114.



(From Allen Thomson.) Diagrams of Primitive Heart and Arteries of an Embryo Chick: *A*, soon after the first establishment of the circulation; *B*, *C*, at a somewhat later period; 1, vitelline veins returning from vascular area; 2, 3, 4, the heart; 5 (above), first aortic arch; 5 (below), dorsal aorta; in *B* and *C* the two primitive aortæ are shown partially united to form the permanent dorsal aorta; 6, vitelline or omphalo-meseraic artery; 5, continuation of aorta beyond the origin of the vitelline artery.

blood, and their fusion is carried farther back, so as to extend into the pelvic region and form what will become the middle sacral artery of the adult. Meanwhile, however, the posterior limbs and allantois have been developing, and the dorsal aorta gives off great branches on each side (common iliac), arteries which carry blood to those parts. The allantoic (umbilical) arteries are branches of the iliac: after birth they become impervious from the umbilicus as far back as the side of the bladder. The internal iliac and superior vesical arteries are remnants of the proximal portions of the allantoic arteries.

As the neck elongates the aortic bulb becomes lengthened, and gives off successively a second, third, fourth, and fifth pair of arches behind the first pair and running around the pharynx to open into the dorsal aortæ. The second pair of these is represented in *B*, Fig. 114, and the three others are indicated by dotted lines. All the aortic arches are really branchial arteries, and correspond to those permanent vessels in fishes which convey blood to the gills and from the gills to the aorta: in air-breathing vertebrates they are for the most part transient structures and disappear before birth. The embryonic vascular system, with all the aortic arches developed, is represented in Fig. 115. The second and third pairs of arches, however, disappear for the most part before the fourth and fifth appear, so that at no single stage of development would all the arches be present as represented in the figure.

Fig. 115.

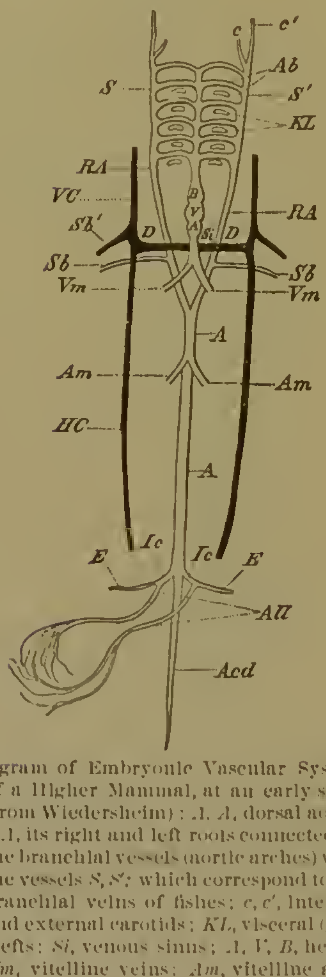
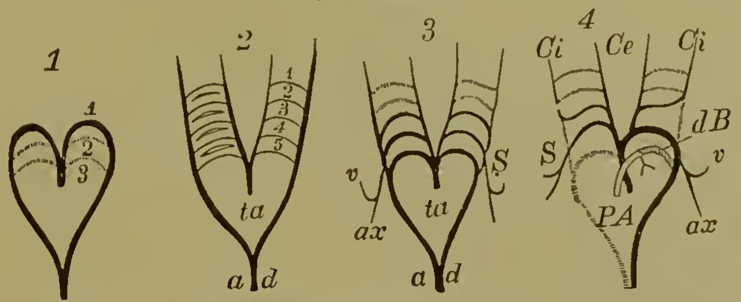


Diagram of Embryonic Vascular System of a Higher Mammal, at an early stage (from Wiedersheim): *A*, *A*, dorsal aorta; *R.A*, its right and left roots connected by the branchial vessels (aortic arches) with the vessels *S*, *S'*; which correspond to the branchial veins of fishes; *c*, *c'*, internal and external carotids; *KL*, visceral (gill) clefts; *Si*, venous sinus; *A*, *V*, *B*, heart; *Vm*, vitelline veins; *Am*, vitelline arteries; *Ic*, common iliac artery; E, external iliac; *All*, allantoic (hypogastric) arteries; *Acd*, middle sacral artery; *VC*, *HC*, anterior and posterior cardinal veins; *Sb'*, subclavian vein; D, anterior vena cava (duct of Cuvier), opening into venous sinus.

The ultimate fate of the various aortic arches of the mammal is shown in Figs. 116 and 117. The middle portions (3, Fig. 116) of the first and second arches disappear: their inner and outer ends remain as the rudiments of the internal and external carotid arteries (*Ci*, *Ce*, 4, Fig. 116), and grow forward into the head. As is clear from the figures, they are supplied with blood from the third arch and from the main stem connecting it with the fourth arch; this stem elongates as the neck increases in length, and becomes the common carotid. The fourth arch on the right side becomes the subclavian. The fourth arch on the left side develops into the permanent aortic arch, and gives off the left subclavian as a branch. The fifth arch on the right side disappears, as do also its dorsal connections with the fourth arch in front of it and with the dorsal aorta behind. The fifth arch on the left side remains until birth as a large trunk (ductus arteriosus, ductus Botalli) opening into the stem leading from the fourth left arch to the dorsal aorta. It gives off two branches (right and left pulmonary) which go to the lungs. Soon after birth the portion of the left fifth arch which lies beyond the pulmonary branches dwindles, and in a few days it becomes an impervious cord, the *ligamentum arteriosum:* its pulmonary branches greatly

FIG. 116.



Diagrams to illustrate the Development of the Aortic Arches (from Landois): 1, the first three pairs of arches, the first pair only fully developed; 2, the five pairs of aortic arches; *ta*, bulbus arteriosus; *ad*, dorsal aorta; 3, stage when the greater portion of the first and second arches has become obliterated; *S*, left subclavian artery; *v*, right vertebral artery; *ax*, right axillary artery; 4, transition to the final stage; *P*, pulmonary artery; *A*, aorta; *S*, right subclavian, continuous with the fourth arch on that side and with the origin of the common carotid; *Ci* and *Ce*, internal and external carotids; *dB*, ductus arteriosus; *v* and *ax*, respectively, the vertebral and axillary arteries of the left side.

enlarge, and its proximal portion remains throughout life as the stump of the pulmonary artery.

FIG. 117.

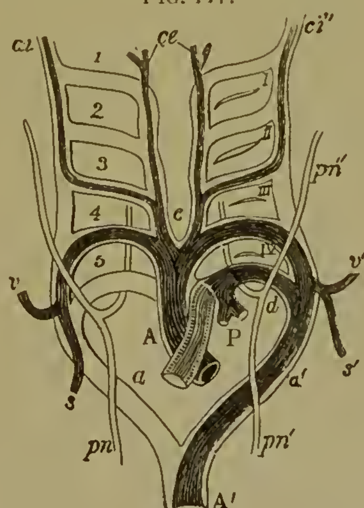
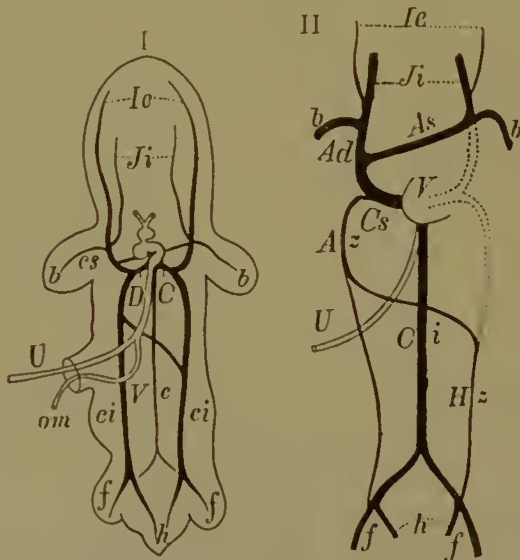


Diagram showing the Primitive Aortic Arches of the Mammal, with their transformations (from Allen Thomson, after Rathke): A, P, primitive aortic bulb, now divided into ascending part of aortic arch, A, and the root of the pulmonary arteries, P; *a*, *a'*, primitive union of aortic arches to form the permanent dorsal aorta, A'; 1, 2, 3, 4, 5, the primitive aortic arches; I, II, III, IV, the branchial (pharyngeal) clefts, omitted on the opposite side for the sake of clearness. The permanent systemic vessels are represented in deep shading, the pulmonary system in lighter shading, and parts of the original arches which are purely temporary are only indicated in outline. *c* lies between the origins of the common carotids; *ci*, *ci'*, internal carotids; *ce*, external carotids; *s*, right subclavian; *v*, right vertebral; *s'* and *v'*, left subclavian and vertebral; P, right and left pulmonary arteries; *d*, ductus arteriosus; *pn*, *pn'*, pneumogastric nerves, illustrating the relationships of their recurrent branches to the primitive and permanent aortic arches.

Long before birth, and while some of the earlier changes of the aortic arches above described are occurring, the septum of the aortic bulb (Fig. 112) has commenced. It divides the cavity of the bulb into two channels, one of which communicates with the fourth pair of arches, the other opens into the fifth. The external constriction indicating the separation of these channels appears later, and divides the root of the aorta from that of the pulmonary artery.

The Development of the Veins.—The earliest formed—and, for some time, the most conspicuous—veins of the human embryo are the vitelline (omphalo-meseraic), which bring blood back from the umbilical vesicle to the sinus venosus of the heart (Figs. 112 and 114), which in turn opens into the rudimentary auricles. The vitelline veins soon fuse together for some distance behind the heart and form a common trunk,

FIG. 118.



Diagrams illustrating the Development of the First Important Veins, except the vitelline and allantoic: *Ic*, anterior cardinal vein, subsequently the external jugular; *Ji*, internal jugular; *b*, subclavian vein: *Dc*, ducts of Cuvier, which become on the right side the superior cava, on the left the coronary sinus; *Ad*, right innominate vein; *As*, cross-branch, which becomes the left innominate vein; *U* and *om*, vitelline veins; in I the left, *U*, is indicated as already larger than the right, *om*; in II the right has entirely disappeared. In I, *ci*, *ci*, the posterior cardinal veins, and *Vc*, the commencing inferior cava; in II, *Ci*, the inferior cava. In both I and II, *f*, external iliac, and *h*, hypogastric vein; in II, *Az*, azygos vein; *Hz*, hemiazygos vein. (From Landois.)

the *meatus venosus:* the right one soon disappears, or at least becomes so reduced in relative size that it appears a mere tributary branch of the left.

The first important veins arising within the body of the embryo are the *cardinal* veins (Fig. 118, I), an anterior and a posterior on each side: the anterior and posterior vessels unite, and from their point of junction a short cross-branch, the Cuvierian duct (Figs. 115 and 118) is given off and opens into the venous end of the heart: the Cuvierian ducts are the rudiments of the right and left superior cavæ.

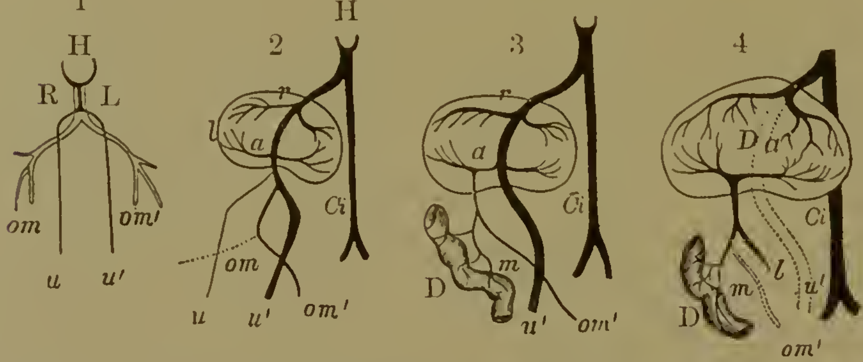
Each anterior cardinal gives off an internal jugular (*Ji*, Fig. 118) and a subclavian (*b*, Fig. 118) branch: its main stem remains for a time conspicuous as the external jugular (*Je*, I, Fig. 118), but subsequently in the human embryo becomes much diminished in relative size as compared with the internal jugular (II, Fig. 118). A transverse anastomosing branch, running obliquely downward from the left to the right anterior cardinal vein, also develops. This cross-branch rapidly increases in size (*As*, II, Fig. 118), and forms ultimately the left innominate vein: nearly all the left anterior cardinal vein below the origin of this branch disappears, so that its blood is carried to the right vein, the part of which below the point of anastomosis with the left innominate is known in human anatomy as the right innominate vein (*Ad*, II, Fig. 118). A part of the lower portion of the left cardinal (or left anterior cava) immediately dorsal to the heart remains pervious and constitutes the coronary sinus of the adult.

The posterior cardinals are at first the only veins which bring back blood from the posterior part of the embryo and from the kidneys. Each divides posteriorly into a hypogastric and an external iliac vein (*h* and *f*, Fig. 118). The inferior cava (*Vc*, Fig. 118, I) is at first very small, and arises by two branches from the points of bifurcation of the posterior cardinal veins. The latter veins are also united by a cross-branch. Ultimately, the inferior cava and its roots, and the hypogastric and iliac veins, enlarge very much (Fig. 118, II). The right cardinal vein remains as the *vena azygos* (*Az*), while the upper part of the left disappears, and its lower part and the cross-branch persists as the *vena hemiazygos*, or the small azygos vein (*Hz*, Fig. 118, II).

The vitelline veins, as already pointed out, open at first into the venous end of the primitive tubular heart (Figs. 115 and 119), and soon fuse for some distance behind the heart to form the meatus venosus; while the left grows so much faster than the right that the latter comes to be a mere branch of the former. The inferior cava as soon as it is formed opens anteriorly into the meatus venosus (2, Fig. 119). The umbilical veins develop with the establishment of the placental circulation (about the fourth week), and (u, u') open also into the meatus venosus. They are at first smaller than the vitelline veins, but with the dwindling of the umbilical vesicle and the growth of the placenta they become larger; the right one (u) soon atrophies, but the left (u') remains as the great umbilical vein until birth.

The umbilical vesicle (Figs. 55 and 56) being an outgrowth of the splanchnopleure, as is also the heart essentially, its veins run, of course, in the mesoblastic layer of the splanchnopleure to the heart. The portions of the splanchnopleure next the embryo form (p. 186) most of the alimentary canal, and veins from this region of it appear as the alimentary tube is closed in. They join the umbilical vein near its entry into the meatus venosus, and are at first insignificant in size. But as stomach, intestines, liver, pancreas, and spleen develop, and the umbilical vesicle shrivels, the veins from the alimentary tube and its dependencies come to be more and more conspicuous, and the vitelline veins to be of less relative size and importance. In this way it comes

Fig. 119.



Development of Some of the Veins (from Landois): H, heart: R and L, respectively, the right and left sides of the body; *om* and *om'*, right and left vitelline veins; *u* and *u'*, the right and left allantoic veins; *Ci*, inferior cava; D, intestine; *m*, mesenteric veins; *a*, venæ advehentes; *r*, venæ revehentes; *l*, splenic vein; *Da*, remnant of ductus venosus, forming the round ligament of the liver.

about that the veins of the "chylopoietic" viscera become much more important than those of the yelk-sac (umbilical vesicle): they ultimately form the portal system.

The liver (p. 188) is an outgrowth from the embryonic portion of the splanchnopleure, and develops around the meatus venosus (2, Fig. 119). The conjoined vitelline (*om'*) and allantoic (umbilical) veins (*u'*) pass through it on their way to the meatus venosus, which by this time is no larger than the inferior cava. The part of the meatus which lies in contact with the liver is known as the *ductus venosus*. It gives off branches (the venæ advehentes, *a*, Fig. 119, 2 and 3) to the liver, and these branches end in capillaries which unite to form the *venæ revehentes* (*r*), which are the rudiments of the hepatic veins. Blood returning from the placenta by the umbilical vein (*u'*, 2 and 3, Fig. 119), from the umbilical vesicle by the vitelline vein (*om'*), and from the alimentary canal by the roots (*m*) of the mesenteric, gastric, and splenic veins, may reach the heart either directly through the ductus venosus, or indirectly through the advehent and revehent (hepatic) veins. After birth (see 4, Fig. 119) the vitelline vein (*om'*) disappears; the allantoic or umbilical vein (*u'*) also becomes obliterated, its remnant in extra-uterine life being a fibrous cord known as the *round ligament* of the liver. Thus after birth the only venous blood reaching the liver comes from the gastric, splenic, pancreatic, and mesenteric veins, which unite to form the *portal vein.*[1]

The Fœtal Circulation in the Last Stage of Pregnancy.—It is obvious from statements made in the preceding pages that the fœtal circulation varies greatly at different periods of embryonic development. There is a first stage, during which the circulation through the walls of the umbilical vesicle is the most important; this soon gives way to a second stage, in which the placental (allantoic) circulation is predominant. As the embryo increases in size and its limbs develop, the circulation within the body proper of the embryo becomes relatively more and more important, and the condition existing in the last weeks preceding birth may justifiably be named a third stage, which is modified after parturition into the extra-uterine or fourth stage.

The fœtal circulation in the third stage is represented in Fig. 120, drawn by Allen Thomson, from whom also is taken the following account of the circulation at birth and the changes in it which soon follow birth:

Fig. 120.

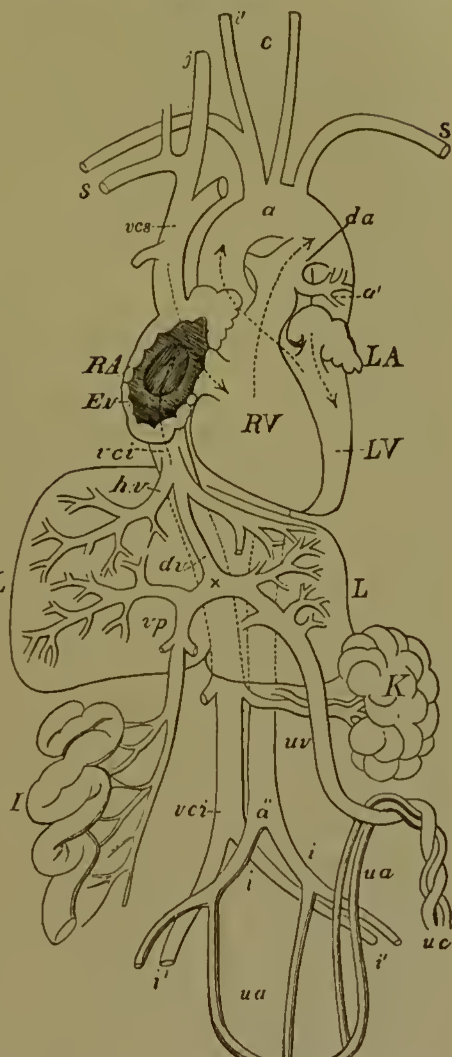


Diagram of the Circulatory Organs of the Human Fœtus at Six Months (Allen Thomson): *RA*, right auricle; *RV*, right ventricle; *LA*, left auricle; *Ev*, Eustachian valve; *L*, liver; *K*, left kidney; *I*, part of small intestine; *a*, aortic arch; *a'*, its dorsal part; *a''*, posterior end of abdominal aorta; *vcs*, superior vena cava; *vci*, inferior vena cava near its junction with the right auricle; *vci'*, posterior part of inferior cava; *s*, subclavian vessels; *j*, right jugular vein; *c*, common carotid arteries: the four dotted arrow-lines indicate the course of the circulation; *da*, ductus arteriosus: an arrow-line starting at *vci* indicates the course of blood-flow from the inferior cava through the foramen ovale; *hv*, hepatic veins; *vp*, vena portæ; *x* to *vci*, the ductus venosus; *uv*, umbilical vein; *ua*, umbilical arteries; *uc*, umbilical cord; *i*, *i'*, iliac vessels.

"The *foramen ovale* retains the form of a free oval opening in the septum auricularum up to the

[1] Even among the higher mammals the development of the great veins varies considerably: the statements given in the text must therefore be considered as applying only to the human embryo.

fourth month, but in the course of that month and the next the valvular plate or curtain [see p. 174] which [lies on the left side] of the fossa ovalis becomes complete, so that in the last three and a half months the blood can only pass from the right into the left auricle, but not in a contrary direction.

"The *Eustachian valve* constitutes a crescentic fold of the lining membrane of the heart, which is so situated as to direct the blood entering the auricle by the inferior cava toward the opening of the foramen ovale.

"The *ductus arteriosus* (Figs. 112 and 117) establishes a connection between the main pulmonary artery and the aorta, by which the blood from the right ventricle is carried mainly into the dorsal aorta.

"The two large hypogastric or umbilical arteries, prolonged from the iliac arteries, passing out of the body of the fœtus, proceed along the umbilical cord to be distributed in the fœtal portion of the placenta. From the placenta the blood is returned by the umbilical vein, which, after entering the abdomen, communicates by one branch with the portal vein of the liver, and is continued by another, named the *ductus venosus*, into . . . . the main stem of the vena cava inferior.

"The right auricle of the fœtal heart [at this stage] receives blood from the two [upper and lower] venæ cavæ and the coronary vein. The blood brought by the superior cava is simply the venous blood returned from the head and upper part of the body; whilst the inferior cava, which is considerably larger than the superior, conveys not only the blood from the lower half of the body, but also that which is returned from the placenta and from the liver. This latter stream of blood reaches the vena cava inferior partly by a direct passage—the *ductus venosus*—and partly by the hepatic veins, which bring to the vena cava inferior all the blood circulating through the liver, whether derived from the supply of placental blood entering that organ by the umbilical vein or proceeding from the vena portæ or hepatic artery.

"The blood of the superior vena cava, passing from the right auricle into the right ventricle, is thence propelled into the trunk of the pulmonary artery. A small part of it is distributed through the branches of that vessel to the lungs, and returns by the pulmonary veins to the left auricle; but, as these vessels remain comparatively undilated up to the time of birth, by far the larger part passes through the ductus arteriosus into the dorsal aorta, and is thence distributed in part to the lower half of the body and its viscera, and in part is conveyed along the umbilical arteries to the placenta. From these several organs it is returned by the vena cava inferior, the vena portæ, and the umbilical vein, and, as already noticed, reaches the right auricle through the trunk of the inferior cava.

"Of the blood entering the heart by the inferior vena cava, only a small part is mingled with that of the superior cava, so as to pass into the right ventricle; by far the larger portion, directed by the Eustachian valve through the foramen ovale, flows into the left auricle, and thence, together with the small quantity of blood returned from the lungs by the pulmonary veins, passes into the left ventricle, whence it is sent into the arch of the aorta to be distributed almost entirely to the head and upper limbs."

Changes in the Circulation at Birth.—"The changes which occur in the organs of circulation and respiration at birth, and which lead to the establishment of their permanent condition, are more immediately determined by the inflation of the lungs with air in the first respiration, the accompanying rapid dilatation of the pulmonary blood-vessels with a greater quantity of blood, and the interruption to the passage of blood through the placental circulation. These changes are speedily followed by shrinking and obliteration of the ductus arteriosus in the space between the divisions of the right and left pulmonary arteries and its junction with the aorta, and of the umbilical arteries from the hypogastric trunk to the place of their issue from the body by the umbilical cord; by the cessation of the passage of blood through the foramen ovale; and, somewhat later, by the closure of that foramen and by the obliteration of the umbilical vein as far as its entrance into the liver, and of the ductus venosus within that organ.

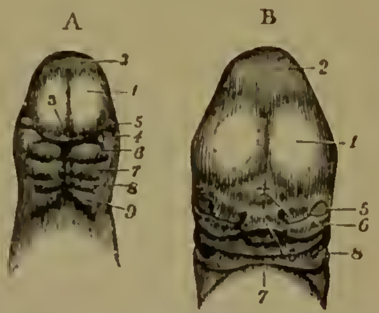
"The process of obliteration of the arteries appears to depend at first mainly on the contraction of their coats; but this is very soon followed by a considerable thickening of their substance, reducing rapidly their internal passage to a narrow tube, and leading in a short time to final closure, even although the vessel may not present externally any considerable diminution of its diameter. It commences at birth, and is perceptible after a few respirations have occurred. It makes rapid progress in the first and second days, and by the third or fourth day the passage through the umbilical arteries is usually completely interrupted. The ductus arteriosus is rarely found open after the eighth or tenth day, and by three weeks it has in almost all instances become completely impervious.

"The process of closure in the veins is slower, there not being the same thickening or contraction of their coats; but they remain empty of blood and collapsed, and by the sixth or seventh day are generally closed.

"Although blood ceases at once to pass through the foramen ovale from the moment of birth, or as soon as the left auricle becomes filled with the blood returning from the lungs and the pressure within the two auricles is equalized, yet the actual closure of the foramen is more tardy than any of the other changes now referred to. It is gradually effected by the union of the fore part of the valvular fold [or curtain on the left side] of the fossa ovalis with the margin of the annulus; but the crescentic margin is generally perceptible in the left auricle as a free border beyond the place of union, and not unfrequently the union remains incomplete, so that a probe may be passed through the reduced aperture. In many cases a wider aperture remains for more or less of the first year of infancy, and in certain instances there is such a failure of the union of the valve as to allow of the continued passage of venous blood, especially when the circulation is disturbed by over-exertion, from the right to the left auricle, as occurs in the malformation [causing] the morbus cœruleus."

The Visceral Arches and Clefts.—Closely connected in developmental history with the aortic arches are certain structures known as the visceral, or branchial, arches and clefts. These are primarily four pairs of slits on the sides of the neck, which in fishes and many amphibia remain throughout life as the gill-clefts extending from the exterior surface to the pharyngeal cavity. According to recent investigations, these slits are imperfect in the embryos of existing birds and mammals, being closed by a thin membrane. The first to appear is the most anterior, and the others follow in regular order: in a human embryo of three weeks three pairs of the gill-clefts are present, and very soon the fourth appears (Fig. 121, A). The front edge of each cleft grows out into a

FIG. 121.



(From Quain's *Anatomy*, after Ecker.) A, from a human embryo of about three weeks: 1, cerebral vesicle or developing cerebral hemisphere; 2, the inter-brain or diencephalon; 3, frontal process; 4, superior maxillary plate; 5, eye; 6, inferior maxillary plate; 7, second branchial arch; 8, third; 9, fourth: posterior to each of these is the corresponding visceral or branchial cleft.

B (from an embryo of about five weeks): 1, 2, 3, 5, as in A; 6, superior maxillary plate; 7, inferior maxillary; 8, outer part of first cleft, which becomes the external auditory meatus.

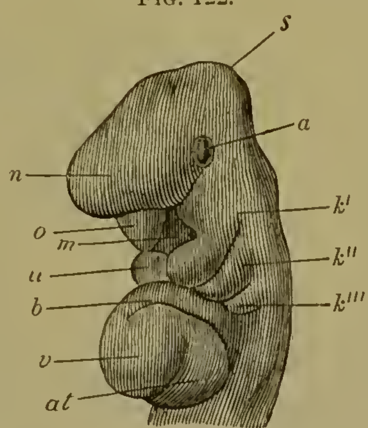
Beneath 3 in A is seen the aperture of the stomadæum.

prominent ridge, the visceral or branchial arch, as does ultimately the posterior edge of the hindmost slit: there are therefore five arches on each side. The aortic arches run at first in the corresponding branchial arches. In man the clefts very soon are obliterated (during the second month) except the first, of which the external auditory meatus, the tympanic cavity, and the Eustachian tube are modified remnants. In the first, second, and third arches skeletal structures develop which take part in the formation of the upper and lower jaws and of the hyoid.

The mouth, or rather the primitive bucco-nasal cavity, arises (p. 121) as a pit lined by epiblast, and ultimately opening into the anterior end of the primary alimentary canal: this pit is the stomadæum. The first pair of visceral arches (6, A, Fig. 121) lie on its posterior or lower side, and are known as the *inferior maxillary plates*: each of them gives off a process, 4, directed medially and forward—the *superior maxillary plate.*

Meanwhile, there has grown backward or downward from the head the *frontal process* (3, Fig. 121). It meets on each side a superior maxillary plate, and forms the upper boundary of the bucco-nasal cavity (Fig. 122). A side view of the head of a human embryo at this stage (about four weeks) is shown in Fig. 123. On each side of the frontal plate a pit (the *nasal pit*, *n*, Fig. 122) appears. From it a groove runs back; passing beneath the fused frontal and superior maxillary plates, it forms there a tube which opens into the stomadæum (Fig. 125). The primitive nostril-chamber of the embryonic mammal therefore opens directly into the front of the roof of the mouth—a condition which is permanent in the frog and many other animals. In the human embryo the subsequent development of the hard and soft palates divides the stomadæum into a buccal and a nasal part, and throws back to the pharynx the communication between the respiratory and alimentary tubes. In the human embryo the hard palate is closed about the ninth week, and a downgrowth from the frontal process above it forms the nasal septum. These normal transformations may not be completed: if the frontal process does not fuse with the superior maxillary plate, the mouth remains imperfectly separated from the nose: if the defective development affects only the soft parts, the result is hare-lip (single or double as the case may be); if it extends to the palatal plates of the superior maxillary and palatine bones, the result is cleft palate.

FIG. 122.



(From Kölliker.) Head of Embryo Rabbit of Ten Days: *a*, eye; *at*, auricular portion of heart; *b*, arterial bulb; *k'*, *k''*, *k'''*, first, second, and third visceral arches; *m*, stomadæum; *o*, superior maxillary process; *u*, inferior maxillary plate; *s*, diencephalon; *b*, region of cerebral vesicles; *v*, ventricular portion of heart.

In the inferior maxillary plate a cartilaginous rod (Meckel's cartilage) develops. Its upper end ossifies in mammals to form the malleus; most of the remainder is absorbed, the lower maxillary bone being developed mainly in membrane which surrounds the primitive cartilage.

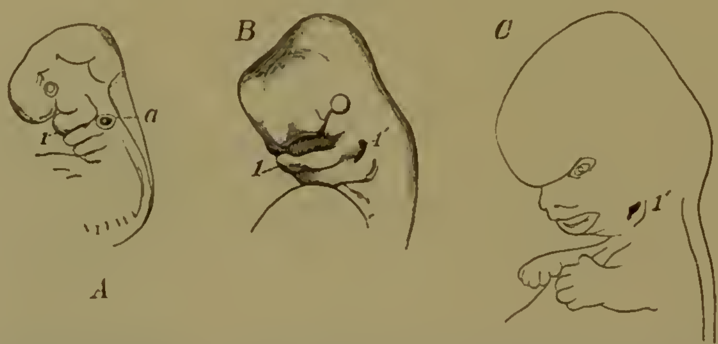
The ankylosis of the inferior maxillæ at the chin occurs toward the end of the first year of extra-uterine life.

The second visceral arch is known as the *hyoidean*, and develops a cartilaginous rod within it. This rod is connected above with the temporal bone, and gives rise to the styloid process, the stylo-hyoid ligament, and the small cornu of the hyoid bone. Whether the incus and stapes are derived from it or from the first arch is still doubtful.

The cartilages which develop in the third branchial arches give origin in man to the body and great cornua of the hyoid.

Of the cartilaginous skeleton of the fourth arch the thyroid cartilage is a modified remnant. The cartilage of the fifth arch disappears

Fig. 123.



Profile View of Head and Neck of Human Embryo, of about four weeks (from Quain's *Anatomy;* magnified ten diameters): *a*, auditory pit; 1, inferior maxillary plate: following it are the second, third, and fourth visceral arches, and the branchial clefts separating them.

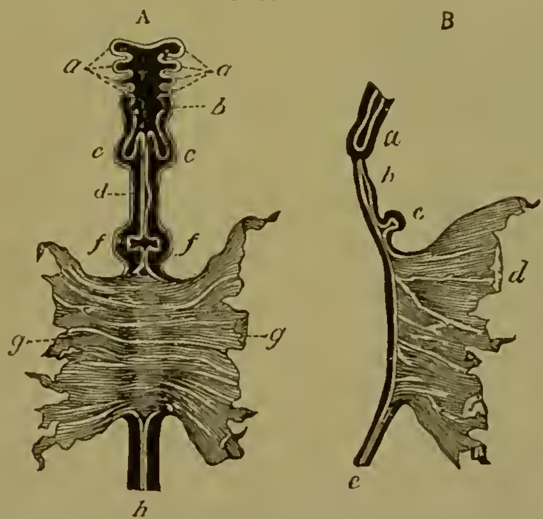
entirely in man. In vertebrates which breathe air dissolved in water it remains as a branchial arch, bearing gills, and has several others behind it.

The condition known as *cervical fistula* is due to the imperfect closure of some one or other branchial cleft behind the first.

The Development of the Alimentary Canal.—The origin of the primitive alimentary canal, or *archenteron*, as a tube formed by infolding of the splanchnopleures has already been described, as also the continuity of its walls with those of the umbilical vesicle. To this archenteron are subsequently added an anterior portion (stomadæum) and a posterior (proctodæum); both of these are lined by epiblast and pitted in from the exterior (Figs. 43 and 57).

The archenteron soon shows a differentation into three regions: the part of it which lies originally within the head-fold is known as the *fore-gut*; from it the lungs, pharynx, gullet, stomach, and duodenum are derived. The posterior portion of the archenteron is short and lies within the tail-fold; most of the rectum is formed from it, as also the allantois and its derivatives (urinary bladder, etc.): it is named the *hind-gut.* The median portion of the archenteron remains for a considerable period open on its ventral side, where its walls spread apart to form the umbilical vesicle (Fig. 124). It is known as the *mid-gut* or *mesenteron,* and is at first relatively short: as it closes-in it elongates and forms the greater part of the small and large intestines.

Fig. 124.



(From Kölliker, after Bischoff.) The Alimentary Canal at an Early Stage. A, from the ventral side; B, in longitudinal section.

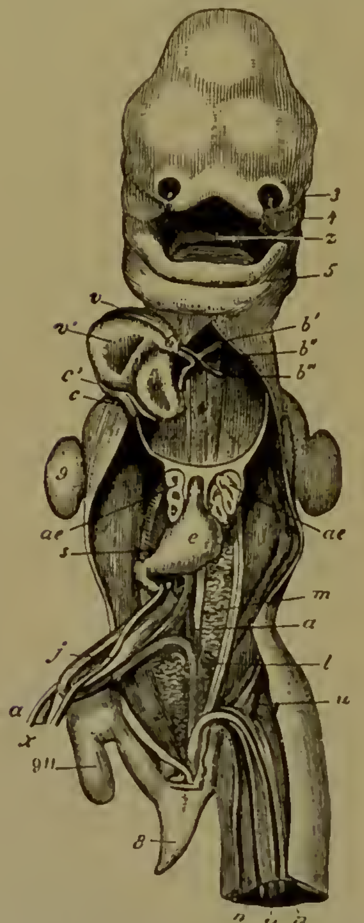
In A the letters *a* indicate four branchial clefts; *b*, the pharynx; *c,c*, the commencing lungs; *d*, the stomach; *f*, commencing liver; *g*, part of umbilical vesicle into which the mesenteron opens; *h*, hind-gut. In B, *a*, the commencing lungs; *b*, the stomach; *c*, the liver; *d*, proximal part of umbilical vesicle.

The fore-gut elongates as the embryo develops, and extends from the head to the abdominal region: part of it dilates quite early in development and forms the rudiment of the stomach (Fig. 125). Beyond the stomach it continues as the duodenum; from this portion the liver and pancreas are developed.

The mid-gut, where its aperture of communication (*ductus vitello-intestinalis*) with the umbilical vesicle narrows, is a nearly straight tube lying close under the vertebral column. As it elongates it forms loops which for the most part bend ventrally—that is, away from the region of the dorsal vertebræ. These loops, however, still remain attached to the mesoblast of the dorsal side of the abdominal cavity by a thin membrane, the rudiment of the mesentery, mesocolon, and so forth. The mesentery is represented in very diagrammatic form in Fig. 39: by comparison of this figure with others (36 and 69) it will easily be seen that the mesenteric folds are produced by a transverse thinning and a dorso-ventral increase of the original wide and short mesoblastic layer attaching the dorsal wall of the mid-gut to the somatic mesoblast.

The first-formed loop of the mesenteron is partly small, partly large intestine. The point of separation of the two is soon indicated by lateral outgrowth, the rudiment of the *cæcum*, which arises just posterior to the most projecting region of the loop. As the small intestine develops, the portion of it behind the duodenum becomes more and more coiled, and some of these coils (Fig. 127) lie at first in the proximal end of the umbilical cord: these are withdrawn into the abdominal cavity about the end of the third month.

Fig. 125.



Human Embryo of about Five Weeks, seen from the ventral side (from Kölliker, after Coste): 3, external nasal process of frontal process; 4, superior maxillary plate; 5, inferior maxillary plate; z, tongue; b, arterial bulb; b', third aortic arch; b'', fourth aortic arch; b''', fifth aortic arch; c, superior cava and right azygos veins; c', the sinus venosus; c'', the common stem of the left anterior vena cava and the left azygos vein; o', left auricle of heart; r, right auricle; r', left ventricle; ae, lungs; e, stomach; j, left umbilical vein; s, continuation of same behind the pylorus, which subsequently becomes the portal vein; x, vitello-intestinal duct; a, right umbilical artery; m, Wolffian body; l, rectum; n, allantoic artery; u, allantoic (umbilical) vein; 3, the tail, which is subsequently lost in the human embryo; 9, rudiment of fore limb; 9'', rudiment of hind limb. The placenta, the liver, and most of the umbilical vesicle have been removed from the embryo.

The large intestine is at first of less diameter than the small. The cæcum is at first a uniform tube lying in the proximal dilated portion of the cavity of the umbilical cord: its separation into cæcum proper and vermiform appendix occurs later.

The hind-gut not only gives origin to most of the rectum, but to the allantois and urinary bladder, and its development is so intimately connected with that of the external genito-urinary organs that it seems best to consider it in connection with them.

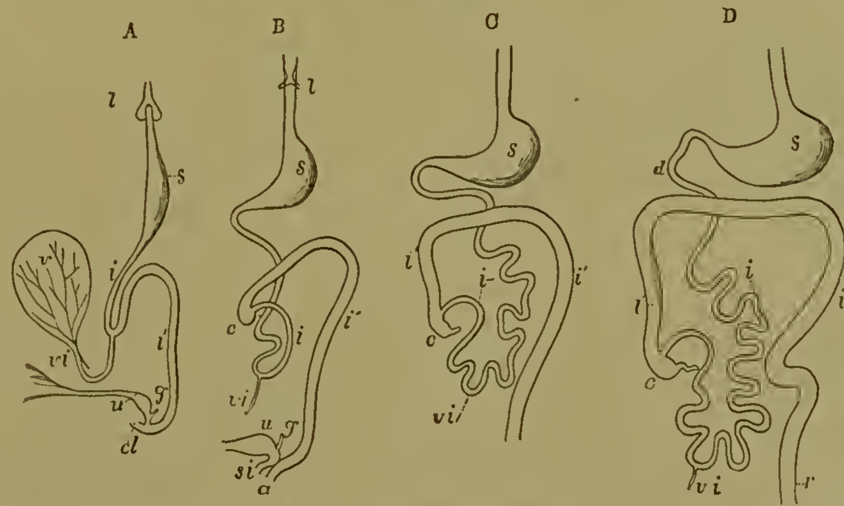
In Fig. 126 are diagrams illustrating the development of the alimentary canal and its structure at various stages.

The umbilical duct is at the third month normally a mere thread or cord attached to the ileum: sometimes its proximal end remains dilated throughout life as a diverticulum from the intestine.

The various forms of umbilical hernia are in general due to a greater or less persistence of fœtal stages in which part of the intestine extends into the umbilical cord (Fig. 127).

The Development of the Liver.—This organ arises as a thickening of the mesoblast layer of the duodenum. Into it there extends a pair of tubes opening into the alimentary canal and lined by hypoblast cells (Fig. 128). From these tubes, which are the primitive hepatic ducts,

FIG. 126.



(From Quain's *Anatomy*.) Diagrams of the Human Alimentary Canal at successive stages of development: A, from embryo of five weeks; B, from embryo of nine weeks; C, ten weeks; D, twelve weeks; *l*, lungs sprouting out from the pharynx; *s*, stomach; *d*, duodenum; *i*, small intestine; *i'*, large; *c*, cæcum and vermiform appendix; *r*, rectum; *cl*, in A, the cloaca; *a*, in B, the anus distinct from *si*, the urogenital sinus; *v*, the yelk-sac; *vi*, the vitello-intestinal duct; *u*, the urinary bladder and urachus leading to the placenta; *g*, the genital ducts. In B and C the diameter of the colon is erroneously represented as greater than that of the ileum.

anastomosing cords of hypoblast burrow through the organ: they give

FIG. 127.

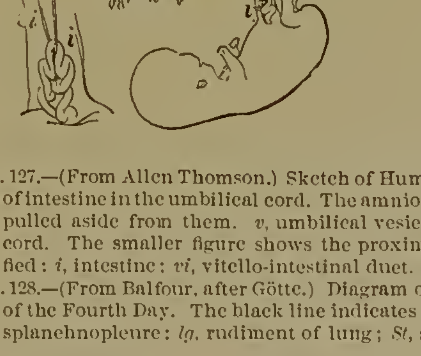


FIG. 128.

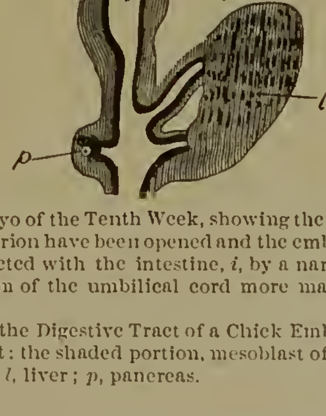


FIG. 127.—(From Allen Thomson.) Sketch of Human Embryo of the Tenth Week, showing the coil of intestine in the umbilical cord. The amnion and chorion have been opened and the embryo pulled aside from them. *v*, umbilical vesicle, connected with the intestine, *i*, by a narrow cord. The smaller figure shows the proximal portion of the umbilical cord more magnified: *i*, intestine; *vi*, vitello-intestinal duct.

FIG. 128.—(From Balfour, after Götte.) Diagram of Part of the Digestive Tract of a Chick Embryo of the Fourth Day. The black line indicates hypoblast: the shaded portion, mesoblast of the splanchnopleure: *lg*, rudiment of lung; *St*, stomach; *l*, liver; *p*, pancreas.

rise to the true hepatic cells. The relation of the allantoic (umbilical), vitelline, and mesenteric veins to the developing liver has been already described (p. 180).

The Development of the Pancreas is essentially like that of the liver. It originates a little more posteriorly on the primitive duodenum. Its gland-cells are derived from the hypoblast of the alimentary tube, and the rest of its tissues (except nerve-fibres) from the mesoblast.

The Lungs (Fig. 128) are a pair of hollow outgrowths from the fore-gut, lined by hypoblast and covered by mesoblast. The first indication of them is (Fig. 129) a dorso-ventral elongation of the primitive œsoph-

Fig. 129.

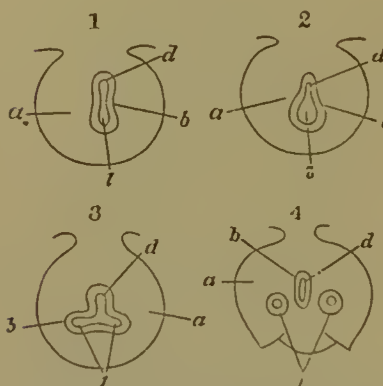


Fig. 130.

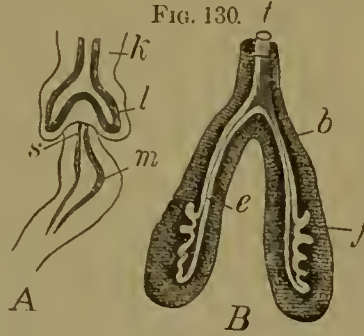


Fig. 129.—(From Balfour, after Götte.) Diagrams illustrating the Origin of the Lungs: *a*, mesoblast of œsophageal portion of splanchnopleure; *b*, hypoblast; *d*, cavity of alimentary canal; *l*, cavity of pulmonary diverticulum. In 1 the fore-gut has begun to divide into dorsal and ventral tubes; the dorsal becomes the pharynx or gullet; the ventral, the larynx and trachea. In 2, the laryngo-tracheal tube has become expanded laterally. In 3, it is shown as subdividing into two tubes communicating with one another and with the alimentary canal. In 4 the subdivision is completed posteriorly, and the cross-section shows the bronchi quite separate from one another and from the fore-gut.

Fig. 130.—(From Landois.) *k*, mesoblast of splanchnopleure; *l*, hypoblast; *m*, stomach; *s*, lower part of œsophagus; *t*, windpipe; *b*, *e*, bronchi; *f*, commencing bronchial tubes and pulmonary air-cells.

agus; a cross-section at this stage is somewhat hour-glass in form, as represented at 1. The dorsal widening of the hour-glass remains as the gullet; the ventral develops into the trachea and bronchi. The trachea before becoming separated from the fore-gut commences to divide into right and left tubes (*l*, Fig. 129, 3). These tubes ultimately diverge posteriorly and form the bronchi (4, Fig. 129), and by branching give rise to the bronchial tubes (Fig. 130), and the vesicular expansion of the ends of these gives origin to the pulmonary alveoli. From the preceding account of their developmental history it will be obvious that the lungs are outgrowths from the ventral side of the anterior portion of the archenteron. They arise just behind the fifth visceral cleft: their epithelium, like that of the trachea and larynx, is derived from hypoblast, while the rest of the pulmonary, tracheal, and laryngeal tissues are derived from the mesoblast of the splanchnopleure.

The *genital* and *urinary organs* are so intimately associated in much of their developmental history that it will be convenient to describe them together.

In some of the lower vertebrates there develop successively three pairs of excretory organs, known as the *pronephros* or head-kidney, the *mesonephros* or Wolffian body, and the *metanephros* or true kidney. There are good grounds for believing that each of these organs primitively consisted of a number of tubes (the segmental tubes), one for each segment of the body, and that each segmental tube opened by one end into the general body-cavity (pleuroperitoneal cavity), and by another into a special duct leading to the exterior. The duct of the pronephros is a tube recognized in the chick embryo by J. Müller in 1830, and is known by his name. The duct of the mesonephros becomes the Wolffian duct, and that of the metanephros the ureter. In all existing higher vertebrates the development of these parts has become greatly modified from the ancestral method; and perhaps none of the advances in comparative embryology made during the last twenty-five years are more interesting than those which have made plain the origin and hereditary meaning of the genital and urinary ducts.[1]

The Wolffian duct is the first to be easily recognized in birds and mammals. A cross-section of the dorsal region of a chick embryo (Fig. 66) shows it as a solid rod of cells, *Wd*, lying in the angle between the mesoblastic somite and the peripheral mesoblast. This rod has until quite recently been supposed to be of mesoblastic origin. But Flemming (Fig. 131), Hensen, Perényi, and others have proved that

Fig. 131.

(From Haddon, after Flemming.) Transverse Section of Rabbit Embryo at stage when sixteen somites were present—shading diagrammatic: *al*, alimentary canal, still wide open below; *cœ*, cœlome; *ep*, epiblast; *hy*, hypoblast; *icm*, intermediate cell-mass; *nc*, neural canal; *sd*, segmental duct; *som*, somatic mesoblast; *sp*, splanchnic mesoblast.

it arises from the epiblast; which is a fact of fundamental importance. In most annelids (the earthworm, for example) the segmental tubes, opening on their inner end into the cœlome, open also directly on the exterior. In vertebrates (which we have many grounds for believing to have had an annelidan ancestry) the outer ends of the segmental

[1] For a full bibliography up to 1882, see Allen Thomson in Quain's *Anatomy*; references to important later discoveries may be found in Haddon, *Introduction to the Study of Embryology.*

tubes open not immediately on the surface, but into a general segmental duct (Wolffian duct), which opens into the hinder end of the primitive alimentary canal. To account for this fact has long been a difficulty, but now that the Wolffian duct has been found to be epiblastic in origin, it is easy to conceive that in primitive vertebrates the segmental tubes may have opened into a groove on the exterior, and that this groove may, much as the medullary groove, have closed over and been separated from the external epiblast: in this condition we find it in Fig. 131; and as development proceeds it becomes more and more imbedded in mesoblast.[1] The posterior end of this primary segmental duct opens at first into the hind-gut, and later into the urogenital sinus (p. 194).

As development proceeds the Wolffian duct becomes buried deeper (*wd*, Figs. 79, 81) in the mesoblast. Meanwhile, the pleuroperitoneal cavity expands, and the mesoblast cells which lie on its mesial side multiply rapidly and give rise to a projection which extends into the cœlome, especially in the dorsal region of the embryo. This projection is part of the *intermediate cell-mass.* At this stage segmental tubes

FIG. 132.

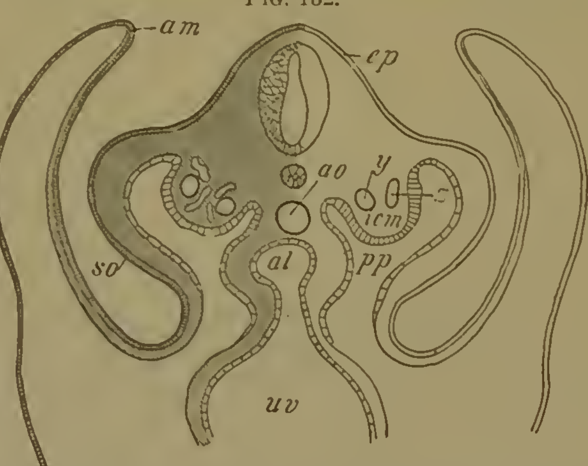


Diagram of Cross-section of Embryo, shortly after the formation of the intermediate cell-mass, *icm*: the peritoneal cells on its surface are seen to have become enlarged; *ao*, aorta; *y*, Wolffian duct, now buried deep in the mesoblast; *z*, duct of Müller: on the left side several Wolffian tubules are shown in section; *al*, alimentary canal; *am*, amnion; *pp*, cœlome.

begin to burrow-in from the body-cavity and to connect with the Wolffian duct. They are the Wolffian tubules, or the tubules of the mesonephros: subsequently they lose their openings into the pleuroperitoneal cavity, which indeed the posterior tubules never possess.

In birds and mammals the pronephros is very imperfectly developed, and lasts only for a very short period. Its duct, however, becomes well marked on each side, and runs back parallel to the Wolffian duct (Fig. 133), to open into the cloaca near the root of the allantois.

[1] See Haddon: *loc. cit.*, p. 250.

The pronephros has at first several openings into the body-cavity: all of these close but one, which remains in the female as the mouth of the Fallopian tube.

In mammals the ureter is the first-formed part of the permanent kidney. Each ureter arises as a tubular outgrowth from near the posterior end of the corresponding Wolffian duct. Extending forward, it enters the intermediate cell-mass just behind the mesonephros. In this mass it branches and forms the uriniferous tubules and their lining

FIG. 133.

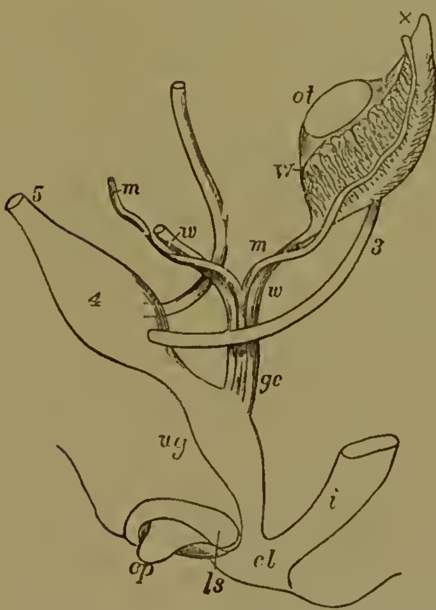


FIG. 134.

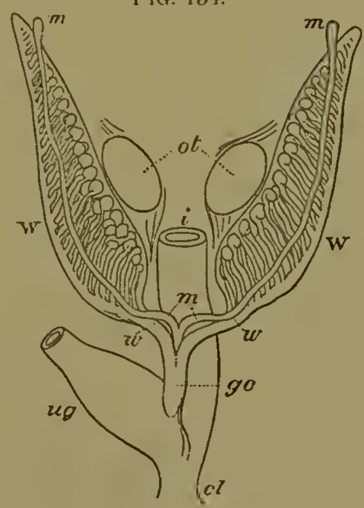


FIG. 133.—(From Quain's *Anatomy*.) Diagram of the Primitive Urogenital Organs of the Human Embryo, before sexual distinction. The posterior parts are drawn chiefly in profile, but the Müllerian and Wolffian ducts are represented as if viewed nearly from the ventral aspect, entire upon the left, but cut short upon the right side of the embryo: 3, ureter; 4, urinary bladder; 5, part of urachus; *ot*, genital ridge from which ovary or testes will develop; W, Wolffian body; ×, its anterior part, from which the coni vasculosi develop; *w. w*, Wolffian ducts; *m*, *m*, Müllerian ducts: these become imbedded near the urogenital sinus, together with the Wolffian ducts, in a cord, the *genital cord; cl*, cloaca; *ug*, urogenital sinus; *i*, rectum; *cp*, rudiment of penis or clitoris; *ls*, rudiment of labium major or scrotum.

FIG. 134.—(From Allen Thomson.) Diagrammatic Outline of the Wolffian Bodies, and their relation to the ducts of Müller and the reproductive glands: *ot*, seat of origin of ovary or testes; *W*, Wolffian body; *w*, Wolffian duct; *m*, duct of Müller; *gc*, genital cord; *ug*, urogenital sinus; *i*, rectum; *cl*, cloaca.

epithelium. Its anterior end, just before the branching commences, dilates to form the pelvis of the ureter. The branching of the uriniferous tubules within the kidneys is a secondary process. There can be little doubt that the ancestral segmental uriniferous tubes were unbranched, and that the same is true of the primitive Wolffian segmental tubes, though these also in the human embryo subdivide and become very numerous.

The ureters soon lose their connection with the Wolffian ducts, and

(3, Fig. 133) form separate openings for themselves into the developing urinary bladder.

The hind-gut, at first closed behind, is (p. 121 and Fig. 43) opened by an ingrowth (the *proctodæum*) from the exterior, which forms the *cloaca* (permanent in the lowest mammals and in birds and reptiles). Into the cloaca the hind-gut and the Müllerian and Wolffian ducts and the ureters at first open. In man and other higher mammals the primitive cloaca soon commences (Fig. 133) to subdivide into a dorsal portion, which receives the hind-gut, *i*, and a ventral portion, *ug*, the urogenital sinus, which is continuous anteriorly with the commencing urinary bladder, 4, and receives on its dorsal side the *genital cord*, *gc*, in which the posterior portions of the Wolffian and Müllerian ducts are contained.

The human urinary bladder (an expansion of the posterior part of the allantoic stalk, p. 129) appears as a fusiform cavity near the end of the second month of intra-uterine life. The ureters at this period open into its dorsal side (Fig. 133), and the urachus (p. 130) has become solid. "The spindle shape of the bladder is retained for a long time in the human fœtus."

The accompanying diagrams (Figs. 135–138) from Stirling, after Schroeder, may be useful as aiding the reader to understand the sub-

Fig. 135.

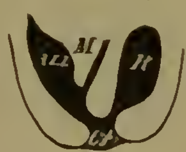


Fig. 136.

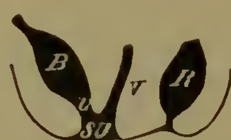


Fig. 137.

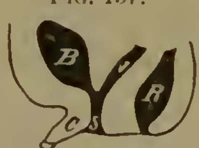


Fig. 138.

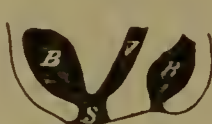


Fig. 135.—CL, cloaca which has opened into primitive hind-gut, and communicates with the rectum and allantois: the posterior portion, ALL, of the latter has commenced to dilate to form the urinary bladder: M, duct of Müller.

Fig. 136.—The cloaca has divided into a ventral portion, SU, the urogenital sinus, which communicates ventrally with the urethra, U, and the bladder, B, and more dorsally with V, the vagina, formed by fusion of the ducts of Müller: R, the rectum.

Fig. 137.—The perineum or tissues separating the rectum from the urogenital sinus are well developed: the neck of the bladder has become constricted to form the primitive urethra, and is separated from the vaginal passage, though both open into the common urogenital sinus, S, and the clitoris, C (in the male the rudiment of the penis) has appeared.

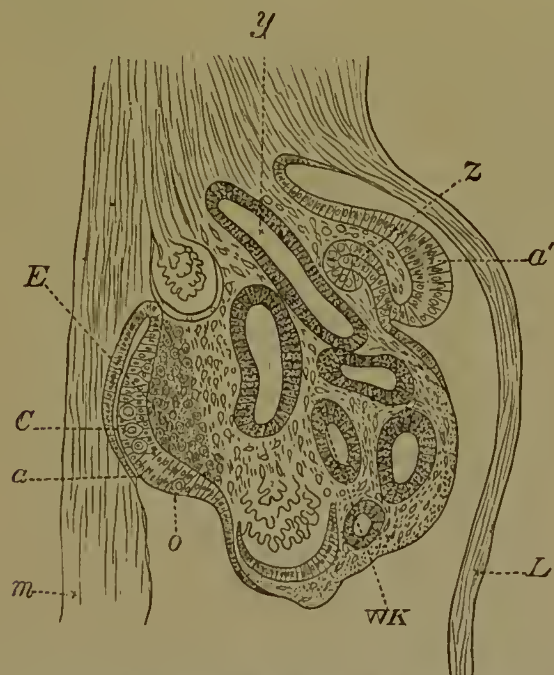
Fig. 138.—The urogenital sinus of the female, S, remains as the cleft between the sides of the external aperture of the labia minora: it communicates in front with the bladder, B, and dorsally with the vagina, V.

division of the primary cloacal chamber, though they refer more especially to the female embryo, and the Wolffian ducts are omitted.

The development of the genito-urinary organs, so far as described in the preceding pages, is common to both sexes. In later stages the duct of Wolff almost disappears in the female, while in the male it constitutes the vas deferens; the Müllerian ducts, on the contrary, atrophy in the male, but form Fallopian tubes, uterus, and vagina in the female.

The Essential Sexual Glands develop in both sexes in close association with the ducts of Wolff and Müller, and in the neighborhood of the mesonephros (*ot,* Fig. 134). The cells lining the abdominal region of the primitive cœlome early become differentiated as its lining epithelium; in most regions they quickly become flat scales, but over the bulging of the intermediate cell-mass (Fig. 132) they enlarge and become columnar in form. These enlarged cells remain for some time over all of the projecting surface of the intermediate cell-mass, and even extend beyond it upon the outer side of the developing mesentery (Fig. 139). They soon become flattened over most of the mass,

Fig. 139.

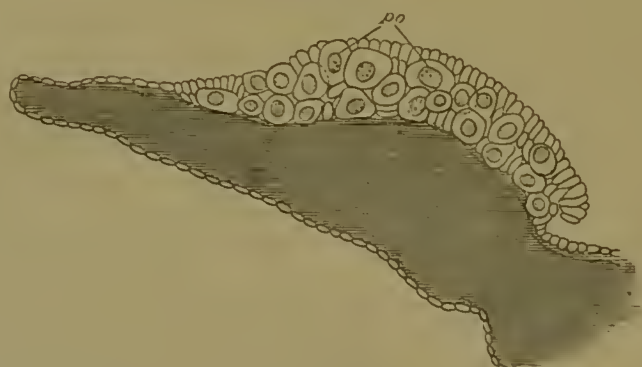


(After Waldeyer.) The Intermediate Cell-mass projecting into the body-cavity, and after the development within it of the Wolffian and Müllerian ducts, and on its mesial side of the germinal epithelium (compare with Fig. 132): *m*, mesentery; L, somatopleure; *z*, duct of Müller, and *a′*, the cells which involute to form its segmental tubes; *a*, germinal epithelium; C, primitive ova within the germinal epithelium; E, commencing stroma of ovary or testis; WK, Wolffian body; *y*, Wolffian duct.

but remain columnar and multiply for some time on its inner and outer sides: on the latter they give origin to the Müllerian duct and some segmental tubes (*a′* and *z*, Fig. 139) and soon cease to be distinct; on the former (C and *o*) they constitute the primitive germinal epithelium. The mesoblast (E, Fig. 139) lying beneath this epithelium gives rise to the blood-vessels and connective tissue (*stroma*) of the ovary or testis, as the case may be. At this stage it is difficult or impossible to detect the sex of the embryo from the structure of the sexual glands.

In the female some cells of the germinal epithelium enlarge (*po*, Fig. 140) to form the primitive ova. Surrounded by other cells from the

FIG. 140.



(From Balfour.) Section through Young embryo *Scyllium*, showing the primitive germinal cells, *po*, lying in the germinal epithelium which covers the mesial side of the intermediate cell-mass in the region of the mesonephros.

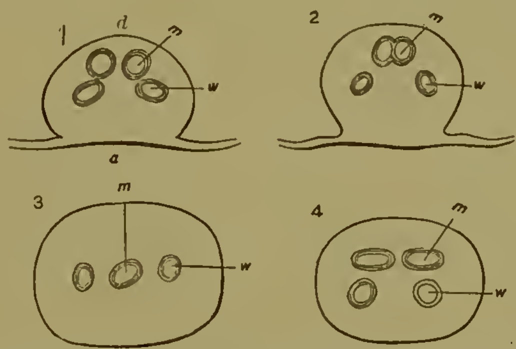
germinal epithelium, they grow into the ovarian stroma as the egg-tubes (Fig. 3), and give rise to the primitive Graafian follicles (p. 70).

The testicle is distinguishable from the fœtal ovary about the eighth week. The cells which in the female form ova, in the male subdivide and give origin to the spermatozoa, while the cells which correspond to the lining cells of the female egg-tubes develop the lining cells of the seminiferous tubules. These canals may be detected in the human embryo of ten weeks; they branch, and during the third month are collected into groups, indicating the lobular subdivision of the adult testis.

The genital cord (*gc*, Figs. 134 and 141) is a cylindrical mass in which, in both sexes, the ducts of Müller and Wolff become imbedded near the urogenital sinus. The four ducts (two from each side) are at first separate (Fig. 141). The Müllerian ducts (2, 3, Fig. 141) coalesce at their lower ends, and in the female enlarge to form the vagina and the posterior portion of the uterus; in the male the lower fused portions of Müllerian ducts remain as the prostatic vesicle, or *uterus masculinus*.

In the female the more anterior portions of the ducts of Müller form the upper part of the body of the womb and the Fallopian tubes: in the male the anterior parts of the Müllerian ducts disappear almost completely, but even in the adult a remnant is to be found on each side between testis and globus major, as the so-called hydatid of Morgagni.

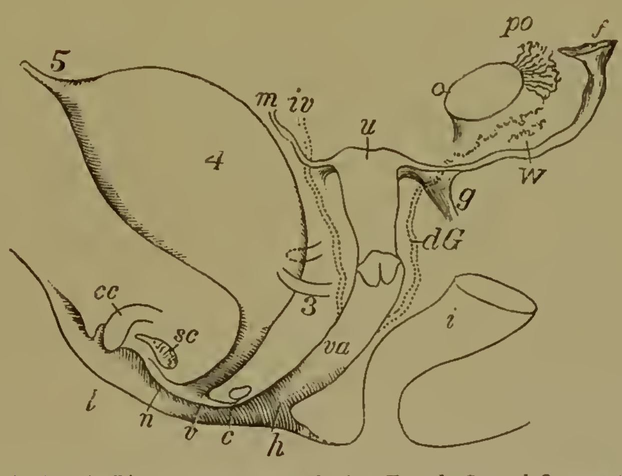
FIG. 141.



(From Quain's *Anatomy*, after Kölliker.) Cross-sections of the Genital Cord of the Embryo of a Female Calf: 1, 2, 3, 4, at different levels, commencing from the front; *a*, ventral, *d*, dorsal aspect; *m*, ducts of Müller; *w*, Wolffian ducts.

The Wolffian ducts become in the male (Fig. 143) the vasa deferentia and ejaculatory ducts: the vesiculæ seminales arise as diverticula from

FIG. 142

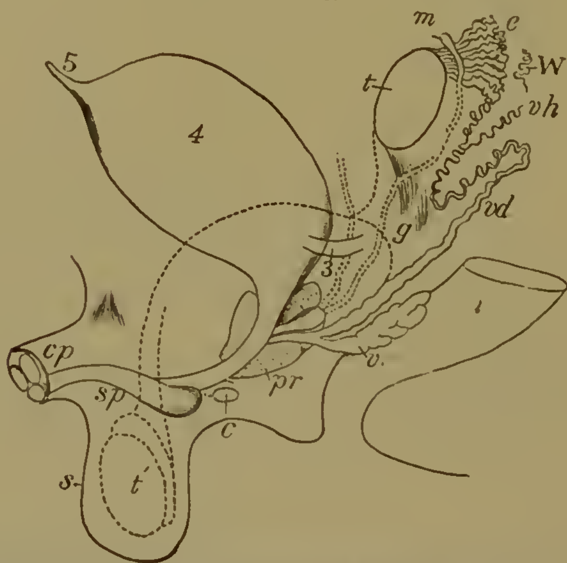


(From Quain's *Anatomy*.) Diagram of the Developing Female Sexual Organs, to be compared with the hermaphrodite primary condition (Fig. 134) and the development of the male organs (Fig. 143): 3, ureter, opening into urinary bladder, 4; 5, urachus; *o*, left ovary, nearly in the place of its original formation; *po*, parovarium or epoöphoron; W, remnants of Wolffian ducts (paroöphoron); *dG*, duct of Gaertner, or remains in female of Wolffian duct; *u*, anterior part of body of uterus, still presenting some trace of its primitive formation from the fusion of the paired Müllerian ducts; *f*, peritoneal opening of left Fallopian tube; *m*, right duct of Müller (Fallopian tube) cut short; *g*, round ligament; *i*, rectum; *va*, vagina; *h*, position of hymen; C, Cowper's gland or gland of Bartholin; *cc*, corpus cavernosum clitoridis; *n*, nympha; *l*, external labium; *v*, vulva.

their lower parts. In the female these ducts almost entirely disappear, but traces of them may be found as the canals of Gaertner (Fig. 142).

Meanwhile, most of the Wolffian body (mesonephros) disappears on each side, but remnants of it may be found in adult men and women. In the female they constitute the parovarium (epoöphoron or body of Rosenmüller, Fig. 142, W). In the male the ultimate fate of some of the Wolffian tubules is more important: they connect (*e*, Fig. 143)

FIG. 143.



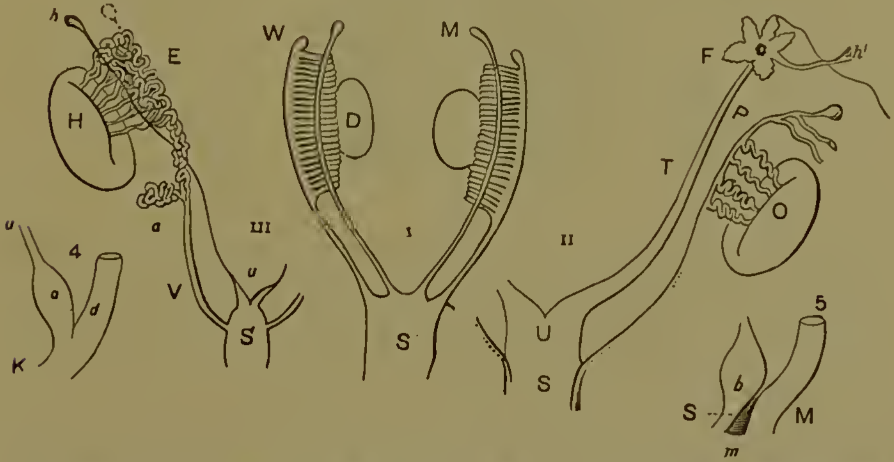
(From Quain's *Anatomy*.) Diagram of the Developing Male Sexual Organs, to be compared with Figs. 134 and 142: 3, ureter; 4, urinary bladder; 5, urachus; *t*, testicle in the place of its origin; *e*, caput epididymis; *vd*, vas deferens; W, remnants of Wolffian tubules, forming the organ of Giraldès or the parepididymis; *vh*, vas aberrans; *m*, duct of Müller, the upper part of which remains as the hydatid of Morgagni: most of its middle portion disappears, but its lower end usually remains as the uterus masculinus; *vs*, vesicula seminalis; *pr*, prostate; C, Cowper's gland; *cp*, corpora cavernosa penis, cut short; *sp*, corpus spongiosum; *s*, scrotum; *t'*, final position of testis: the dotted lines indicate the course of its descent.

the seminiferous tubules of the testis with the epididymis, and form the *coni vasculosi*. Most of the epididymis is formed from the Wolffian duct, which is continued as the vas deferens. The vas aberrans is the relic of some Wolffian tubules.

Descent of the Testicles.—Both the ovary and testicle travel back from the place of their original formation, but the former much less in the great majority of cases. The testis enters the internal inguinal ring during the seventh month of intra-uterine life; by the end of the eighth month it has usually reached the scrotum, and before birth the communication between the peritoneal cavity and the tunica vaginalis is normally closed. In rare cases (p. 91) the ovaries take a similar course and enter the labia majora.

The Development of the External Genitals.—The formation of the cloaca has already been described (pp. 121 and 194) and figured (Figs. 43 and 133), as also its separation in both sexes (Fig. 134) into an anal and a urogenital portion. The urogenital sinus is at first narrow and deep, but soon becomes shallow (Fig. 136), and meanwhile the perineal tissues separate it more and more from the anus. Before the subdivision of the cloaca a genital eminence (*h*, Fig. 145, I) appears at its ventral or anterior end about the sixth week. On each side of the cloacal slit outgrowths of skin and subcutaneous tissue (*w*, Fig. 145, II) become

FIG. 144.

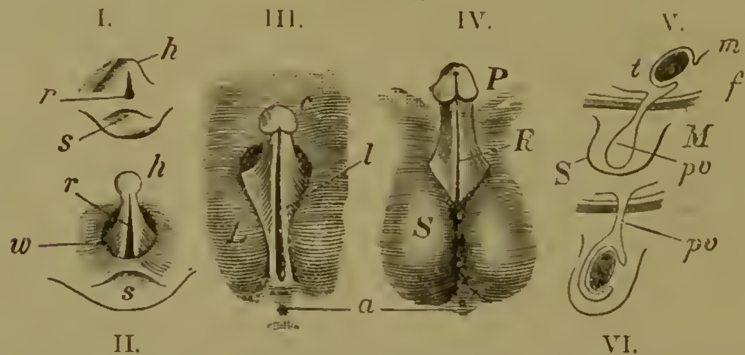


(From Landois and Stirling.) Diagrams to illustrate the Development of the Internal Genital Organs in Both Sexes: I, hermaphrodite or undifferentiated condition: D, ovary or testis, lying upon the tubules of the Wolffian body; W, Wolffian duct; M, duct of Müller; S, urogenital sinus. II, modifications in the female: T, primitive Müllerian duct, forming the Fallopian tube and developing fimbriæ, F, around its peritoneal opening; *h'*, ovarian hydatid; *u*, uterus, forming by fusion of the posterior ends of the ducts of Müller; S, urogenital sinus; O (answering to D in I), ovary; P, parovarium, or remnant of Wolffian body and duct. III, modifications in the male: H, testis, corresponding to D in I; *c*, epididymis; *h*, hydatid of Morgagni; *a*, vas aberrans; V, vas deferens, or Wolffian duct; *u*, uterus masculinus, the remnant of the lower ends of the fused ducts of Müller; S, urogenital sinus.

prominent (see also *ls*, Fig. 133). At the eighth or ninth week there is a groove in the under (posterior) side of the genital eminence, with well-marked side-walls (*r*, Fig. 145) leading back to open into the cloaca. The development of the perineum divides this groove (during the third month) transversely into a smaller anal opening and a larger urogenital. This condition (III, Fig. 145) is but slightly modified in the female. The genital eminence in that sex remains small and constitutes the clitoris (*c*, III, Fig. 145, and *cc*, Fig. 142). The side-walls (*w*, II, Fig. 145) remain separate and form the labia minora (*l*, III, Fig. 145), while the cutaneous folds (*w*, II, Fig. 145) enlarge and become the labia majora (*l*, Fig. 142, and *L*, Fig. 145, III). The urogenital sinus is therefore permanent in woman, and forms the *vestibule*, which has in front of it the clitoris, and, opening into it, the urethra and vagina.

In the male a further development takes place (Fig. 145, IV). The genital eminence enlarges to form the penis, and the groove beneath it closes so as to form the penial urethra. The corpus spongiosum of man is for the most part equivalent morphologically to the nymphæ of the woman, which remain in a separated and more embryonic con-

Fig. 145.



(From Landois and Stirling.) To illustrate the Development of the Human External Genitals: I: *h*, genital eminence; *r*, cloacal aperture; *s*, tail or coccyx of embryo. II: *h*, genital eminence; *r*, cloacal opening; *w*, commencement of labia majora or scrotum, according to sex; *s*, embryonic tail. III, next stage, practically permanent in the female: *c*, genital eminence (clitoris); *l*, nymphæ; *L*, labia majora; *a*, anus. IV, later or male condition: *P*, penis; *R*, edges of embryonic folds infolding to enclose the penial urethra; *S*, scrotum; *a*, anus. V and VI, illustrate the descent of the testicle.

dition. The skin-folds, which remain separate in the female as the labia majora (*L*, III, Fig. 145), coalesce in the male (IV, *S*) to form the scrotum.

THE FŒTUS: ITS PHYSIOLOGY AND PATHOLOGY.

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THE DEVELOPMENT OF THE FŒTUS IN THE DIFFERENT MONTHS OF PREGNANCY.

THE changes in the developing embryo and fœtus[1] that mark its growth from month to month are not only of engrossing interest to the physiologist, but have their practical value for the obstetrician as well when he would determine the probable date of impregnation from the appearance of the cast-off ovum. The importance of such a decision, frequently involving serious medico-legal questions, need only be mentioned to be appreciated. The intelligent explanation of many congenital deformities and intra-uterine accidents and diseases also depends so intimately upon a certain amount of knowledge in regard to the story of intra-uterine development that no further excuse need be offered for occupying space in a practical work with a brief description of some of the more marked changes that occur in the process of transforming a simple cell into the infant at term, with all its future possibilities of thought, speech, and action—the most complex being of animal creation.

First Month.—The life-history of the human ovum during the early part of the first month is involved in considerable doubt. The place in which the spermatic particle and ovule meet, the length of time required for the passage of the latter from the ovary to the uterine cavity, the part that the lining membrane of the oviduct and its secretion plays in the nourishment of the ovule and in the production of certain modifications in the external coat, are all matters yet in dispute; and as direct observation of the human ovum during and shortly after impregnation fails us, we must base our theories as to the site in which this phenomenon occurs, as to the changes that immediately succeed it, upon what has been actually seen to occur in the lower animals

[1] The usual plan of calling the product of conception "embryo" for the first three months, and afterward "fœtus," is the one adopted here.

and upon the clinical history of those pregnancies in which the ovum is developed in an unnatural situation. Thus it is argued that the spermatic particle must penetrate the ovule shortly after its escape from the Graafian follicle, for the occasional occurrence of abdominal and tubal pregnancies proves that the so-called spermatozoa can make their way far into the tube, and even on to the surface of the ovary; and what is seen in animals makes it probable at least either that the outer coating of the ovule, during its passage through the tube, receives an additional thickness from an albuminous deposit upon it, or that the original cell-wall becomes denser and more tough by a process of coagulation; either of which conditions would render the penetration of the ovule by the spermatic particle unlikely if not impossible. On the other hand, it is claimed[1] that if the ovule escapes from the ovary at the beginning of the menstrual flow, and if the fruitful coition occurs only some days after menstruation has ceased, as is common at least among civilized people, the time that intervenes between the rupture of the Graafian follicle and the deposition of semen in the female genital tract has been too great to lend probability to the idea that the ovule still remains in the ovarian extremity of the oviduct, but, on the contrary, would ensure its presence in the uterine cavity. The fact that the cilia of the uterine epithelial cells work upward, while those of the tubes work toward the uterus, is pointed to as corroborative evidence in support of the view that the upper part of the uterine cavity is the meeting-place of spermatic particle and ovule; and it is asserted that the rhythmical contraction of the muscles in the tubal walls which tends to drive the exuded menstrual blood, as well as the ovule, toward the uterus would offer an additional barrier to the ascent of the spermatozoids. This argument is invalidated, however, by the occasional occurrence of extra-uterine pregnancy; and, in spite of the arguments advanced by Wyder and a few others, the prevailing opinion of the present day is that the human ovule becomes fertilized shortly after its expulsion from the ruptured Graafian follicle, most probably in the ampulla of the tube. There has been great difference of opinion in the past as to the manner in which the ovule got from the Graafian follicle, after its rupture, to the orifice of the oviduct, the prevailing idea having been that the fimbriated extremity of the latter became "erected" at the time the ovule escaped, and grasped with its fimbriæ the surface of the ovary, thus displaying a sort of independent intelligence. As, however, the anatomical impossibility of the fimbriæ being closely and accurately applied to the surface of the ovary has been demonstrated,[2]

[1] See Wyder: "Beitr. zur Lehre v. d. Extrauterinschwangerschaft u. dem Orte des Zusammentreffens von Ovulum u. Spermatozoen," *Arch. f. Gyn.*, Bd. xxviii. S. 325.

[2] Henle: *Handb. d. Anat. d. Menschen*, 1864, ii. S. 470; and Bischoff: *Entwickelungsgeschichte*, S. 28.

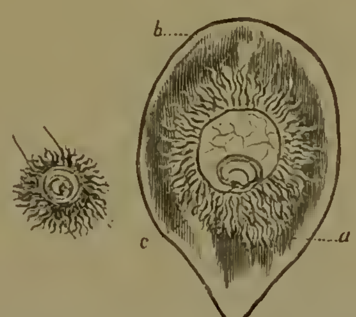
and as the tube contains no true erectile tissue, this theory must fall. The fact that the fimbriæ are provided with ciliated epithelial cells which work actively toward the uterus, and create a stream in the moisture which is always present upon the peritoneal surface, is now held sufficient to account for the transference of the ovule from the ovary to the oviduct. The ovule, being discharged from the Graafian follicle, is either brought directly in contact with the cilia of a fimbria, or else, dropping upon the peritoneum, it is caught in the gentle current of a minute quantity of fluid that always bathes that membrane, and so conveyed to the wide opening of the abdominal end of the oviduct. This explanation will also account for the so-called "external migration" of the ovule, which, discharged from an ovary and failing for some reason to be taken up by the corresponding tube, finds its way to the opposite tube—an occurrence that has been observed in certain cases of tubal pregnancy.[1]

The changes in the ovum immediately before and shortly after impregnation may be passed by.[2] The changes in the uterine mucous membrane preparatory to and after the lodgment of the ovum in one of the depressions formed by the folds into which the hypertrophied mucous membrane is thrown, will be described later. It only remains to notice the successive changes in size and development that would enable one to determine the length of time that had elapsed since impregnation occurred, and to comprehend more fully intra-uterine deformities and diseases.

Fig. 146.

Human Ovum Twelve to Thirteen Days Old (Thomson).

Fig. 147.



An Ovum about Fourteen Days Old, natural size (Hennig): *a*, chorion villi; *b*, blood-clot and decidua reflexa; *c*, embryo.

The youngest human ovum that has been seen was described by Thomson,[3] who estimated its age to be twelve to thirteen days. The embryo in this case was 2 mm. long; the chorion was furnished with thin and simple villi; the allantois was not to be detected; and almost

[1] Wyder: *loc. cit.*

[2] See preceding section.

[3] *Edinb. Med. Journ.*, 1839, vol. lii.

the whole ovum was occupied by the yolk-sac. Other very young human ova have been described by Schroeder van der Kolk,[1] Coste,[2] Hennig,[3] Reichert,[4] Breus,[5] Beigel,[6] Löwe,[7] Kollmann,[8] Ruge,[8] etc. Waldeyer has described a very interesting ovum, just four weeks (twenty-eight to thirty days) old, that measured 19 mm. in length, 16.5 mm. in breadth (about the size of a pigeon's egg), and weighed 2.3 grm. The length of the embryo, in a straight line from cephalic to caudal extremity, was 8 mm., while the actual length of the dorsal line was 20 mm.

FIG. 148.

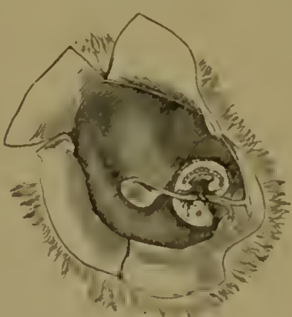


FIG. 149.

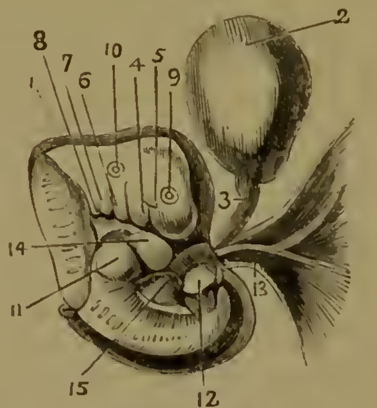


FIG. 148.—Human Embryo *in situ* within its Membranes, 4 weeks old, natural size.

FIG. 149.—Human Embryo in the Fourth Week, magnified: 1, amnion removed in part of the dorsal region; 2, umbilical vesicle; 3, omphalo-mesenteric duct; 4, inferior maxillary tubercle of first pharyngeal arch; 5, superior maxillary tubercle from the same arch; 6, second pharyngeal arch; 7, third; 8, fourth; 9, eye; 10, primitive auditory vesicle; 11, anterior extremity; 12, posterior extremity; 13, umbilical cord; 14, heart; 15, liver.

During the first month the human embryo is indistinguishable from that of other mammals. The ovum at this early period may be described as a double-walled, flattened vesicle filled with fluid. The outer wall bears the branched villi; the inner one is smooth. The connection of the villi with the decidua reflexa, and even with the decidua serotina, is a superficial one, and the ovum is easily separated from its uterine attachments.[9] The yolk-sac, at first occupying nearly the whole ovum, even at the end of the first month is larger than the cephalic extremity of the embryo. The visceral arches are distinct; the limbs are merely rudimentary; the cord is straight, thick, and short; and the amnion is still quite close to the embryo, and is separated from the chorion by a clear space.

As to the embryo itself, during the first month the heart appears as

[1] *Verhandl. d. Ak. d. W. Amsterdam*, iii. 3.
[2] *Histoire du Dévelop.*, pl. iii.
[3] *Arch. f. Gynäk.*, Bd. v. S. 170.
[4] *Abhandl. d. Königl. Ak. d. W. zu Berlin.*
[5] *Wien. Med. Wochenschr.*, 1877, S. 502.
[6] *Arch. f. Gynäk.*, Bd. xii. S. 421.
[7] *Ibid.*, Bd. xiii. S. 482.
[8] *Ibid.*
[9] See Br. Hicks: *Obst. Tr.*, xiv. p. 149; Langhans: *Archiv f. An. u. Phys.*, 1877, 2 u. 3, 14, S. 231; Ahlfeld: *Arch. f. Gyn.*, Bd xiii. S. 231.

a cylindrical body, which soon becomes S-shaped, and by the fourth week displays four distinct cavities and is covered by its pericardium; it is probably functionally active by the third week;[1] the brain and spinal column are enclosed; the intestinal tract becomes also closed over, but the connection with the umbilical vesicle is still a wide one; the first traces of a liver appear; the primitive kidneys may be seen; and toward the end of this period the eyes may be distinguished at the sides of the head and the rudimentary extremities become visible as

FIG. 150.

FIG. 151.

FIG. 152.

FIG. 153.

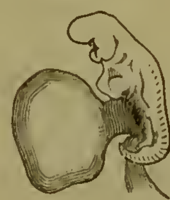


FIG. 154.

FIG. 155.

FIG. 156.

Figures showing Stages of Development during the First Month (His).

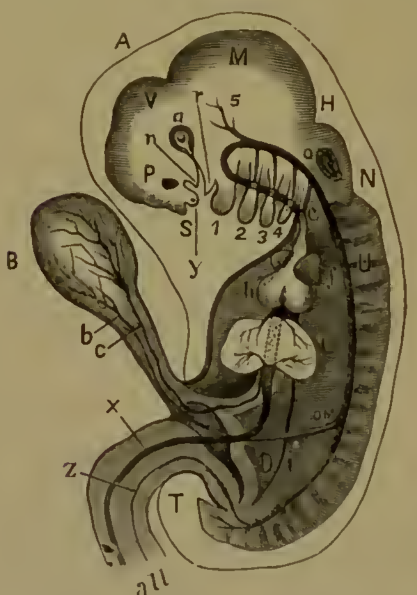
four bud-like processes. The oral and anal orifices of the intestinal tract are formed by depressions in the teguments which open into the extremities of the tract after the absorption and disappearance of intervening tissues.

Second Month.—At the beginning of the second month the ovum is the size of a pigeon's egg, and the embryo measures 8 mm. (.3 inch) in a straight line from head to tail. During this month the embryo grows to 2½ cm. in length and the ovum reaches the size of a hen's egg. The visceral clefts close, with the exception of the first, which eventually forms the external auditory meatus, the cavity of the tympanum, and the Eustachian tube. The first visceral arch, dividing into two branches, forms the superior and inferior

[1] Preyer: *Specielle Physiologie des Embryos.*

maxillary processes. The latter, one from each side, approach one another, and finally unite to form the lower jaw. The superior maxillary processes while approaching one another are kept from uniting by the intervention of the frontal process. At the point of junction of this last process with the two superior maxillary processes there occurs occasionally the deformity known as hare-lip, from the failure of the processes to unite, but as union is always perfect before the end of the second month, the arrest of development that results in this deformity must have taken place at some period prior to the third month—a point to which Parvin[1] has particularly called attention. During the second month from the growth of the viscera the body becomes somewhat straightened out, and from the head increases in size. The umbilical vesicle atrophies, and may be found attached to the body by a slender pedicle. The umbilical ring is somewhat contracted, but still contains a few loops of intestine, so that if at this time an arrest in the development of the abdominal walls should occur, a bad umbilical hernia or exomphalus might be the result. The umbilical cord runs straight to the periphery of the ovum. The eyes occupy a position on the side of the head; behind them may be seen the ears, and in front arises the external nose. The limbs are separated into their three divisions, and the first suggestions of hands and feet appear, with the fingers and toes webbed. The Wolffian bodies are much lessened in size, but the kidneys and suprarenal capsules are now developed. The external genitals now make their appearance, but neither internally nor externally is the sex to be distinguished, for the elements of both sexes are present in equal

Fig. 157.



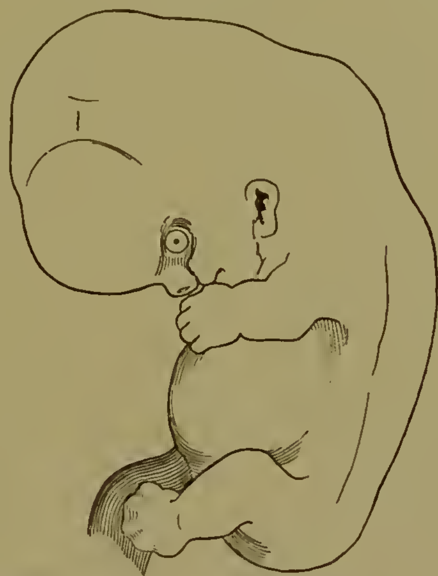
Scheme of a Human Embryo, with the visceral arches still persistent: *A*, amnion; *V*, fore-brain; *M*, mid-brain; *H*, hind-brain; *N*, after-brain; *U*, primitive vertebræ; *a*, eye; *P*, nasal pits; *S*, frontal process; *y*, internal nasal process; *n*, external nasal process; *r*, superior maxillary process of the first visceral arch; 1, 2, 3, and 4, the four visceral arches, with the visceral clefts between them; *o*, auditory vesicle; *h*, heart, with *c*, primitive aorta, which divides into five aortic branches; *f*, descending aorta; *om*, omphalo-mesenteric artery; *b*, the omphalo-mesenteric arteries on the umbilical vesicle; *c*, omphalo-mesenteric vein; *L*, liver, with arriving and departing veins; *D*, intestine; *i*, inferior cava; *T*, coccyx; *all*, allantois, with *z*, one umbilical artery, and *x*, an umbilical vein.

[1] Parvin's *Obstetrics*, 1886, p. 136.

degree.[1] Toward the end of the second month or at the beginning of the third the eyelids appear. There are points of ossification to be seen

Fig. 159.

Fig. 158.



Illustrating the Development of the Embryo in the Second Month (His).

in the lower jaw and clavicle. The villi of the chorion have taken on a more luxurious growth at the point where the future placenta is to be developed, and the fœtus is no longer drawing its nourishment from the umbilical vesicle, but obtains its food from the maternal blood.

Third Month.—During this month the ovum reaches the size of a goose's egg (9.5–11 cm. long), and the embryo grows to a length of 7–9 cm. (2.75–3.5 inches) and weighs about 30 gm. (460 grains). The umbilical cord increases in length to 7 cm. (2.7 inches), and becomes twisted. The umbilical ring is smaller, and the intestines are retracted within the abdomen. The fingers and the toes lose their webbed appearance, and the nails appear as fine membranes. The eyes approach nearer to one another and become protected by the lids. Points of ossification may be found in most of the bones, and the neck now separates the head from the trunk. The ribs, developing, divide the trunk plainly into chest and abdomen; the oral and nasal cavities are separated by the palate; the lips close over the mouth and teeth begin to form in the jaws. The sex may be distinguished by the presence or absence of a uterus; cutaneous folds form a scrotum or the labia majora, but the clitoris and penis are still of equal length. The chorion loses its villi, except at the point where the placenta is developing. The latter, though small, can plainly be distinguished.

Fourth Month.—In the fourth month the fœtus attains a length of

[1] See, later on, the description of hermaphrodites.

10–17 cm. (4–6.75 inches) and a weight of 55 gm. (850 grains).[1] The umbilical cord is still more twisted than in the preceding month, and the placenta is increased in size. The head of the fœtus now amounts to a quarter of the whole length of the body, and the cranial bones are in part ossified, although the fontanelles and sutures gape widely. The sex is plainly to be distinguished, the genital fissure, in the case of a male, having united to form the scrotum, leaving in the median line a very distinct raphé. The future prostate is indicated by a thickening at the point of meeting of the genital cord and the urethra. A fine growth of down appears at this time upon the fœtal skin (lanugo), and a few hairs appear on the scalp. The intestines contain meconium; the limbs may be feebly moved; and the fœtus may live, if born, as long as four hours, without, however, making respiratory efforts (Cazeaux).

Fifth Month.—During this month the fœtus is about 18–27 cm. (7–10.5 inches) long and weighs about 273 gm. (8 oz.). The umbilical cord is about 31 cm. (12 inches) long. The liquor amnii exceeds the fœtus in weight. The head is relatively very large; the face has a senile look and is wrinkled, and the eyelids begin to open. The skin is richer in fat, is covered with lanugo, and in places with vernix caseosa, a sebaceous material containing also epithelial scales and downy hairs. Some time during the fifth month the mother usually experiences "quickening"—that is, the movements of the fœtus—and the fœtal heart-sounds may be heard on auscultation. If the fœtus should be born at this time, it may make efforts to breathe or cry, but dies in a few minutes or at most hours.

Sixth Month.—The fœtus toward the end of the sixth month is 28–34 cm. (11–13.5 inches) long and weighs 676 gm. (23½ oz.). The skin is better supplied with fat, the hairs of the scalp grow longer, eyebrows and eyelashes are distinct. The umbilical cord is now inserted in the middle third between the pubic symphysis and the xiphoid cartilage. The head is still relatively large. The testicles in boys approach the inguinal rings. If a fœtus at this age should be born, it might live from one to fifteen days, but would eventually die from insufficient assimilation of food, from rapid loss of heat, and from imperfect respiration, owing to the undeveloped state of the finer ramifications of the air-passages.

Seventh Month.—At the end of this month the fœtus measures in length 35–38 cm. (13.75–15 in.) and weighs 1170 gm. (41¼ oz.). The whole body is covered with lanugo except the palms of the hands and the soles of the feet. The large intestine contains a considerable quantity of meconium. The pupillary membrane, which had hitherto obscured the pupil, now disappears. A child born between the twenty-

[1] Given by Spiegelberg as Hecker's weights and measurements. Spiegelberg: *Lehrbuch*, tr. by Syd. Soc., p. 118.

fourth and twenty-eighth weeks will almost invariably die. The exceptions to this rule have been very rare in the past, but whether in the future, by the aid of incubators and forced feeding (*gavage*), a larger proportion of these very premature children will be saved remains to be seen. An attempt should, at any rate, always be made to preserve an infant, no matter how puny or ill-developed it may be, as long as its respiration suffices to sustain life; for it may be, as Lusk remarks, that the scepticism of physicians in regard to the possibility of saving these premature children is the cause of the unfavorable results that have been obtained in the past.[1]

Eighth Month.—The fœtus measures now in length 39–41 cm. (15.25–16 in.) and weighs 1571 gm. (3½ lbs.). The hair on the scalp is more abundant, the down on the face is disappearing. One of the testicles, usually the left, has descended into the scrotum. The nails are firmer, but do not yet project beyond the finger-tips. At the end of the eighth month ossification begins in the lower epiphysis of the femur. The cord is inserted a little below (.6–1.2 in.) the middle point, between the xiphoid appendix and the pubic symphysis. A child born at this period may with proper care survive.

Ninth Month.—The length of the fœtus measures 42–44 cm. (16.5–17.25 in.) and the weight is 1942 gm. (4¼ lbs.). There is a decided increase in subcutaneous fat. The nails are not yet perfectly developed. Toward the end of this month, near the thirty-sixth week, the weight will be about 5½ pounds, and the diameters of the skull will be about 1–1.5 cm. less than in a normal fœtus at term.[2] At this period also the bones of the skull are compressible and easily moulded to the shape of the pelvic cavity; and if at this time, about the thirty-sixth week, the infant should be born, with ordinary care it will almost certainly survive. Thus it is that such good results are accomplished in cases of contracted pelves by inducing labor about four weeks before the full time.

[1] There persists even yet in the minds of some general practitioners, as well as among the laity, as the writer can testify, the idea that children born in the seventh month will be more likely to survive than those born at the eighth month. Prof. Parvin (*Science and Art of Obstetrics*) shows how this superstition has descended, through more than two thousand years, from Hippocrates, who explained that the fœtus is placed with its head uppermost in the uterine cavity until the seventh month, when the increasing weight of the head causes it to fall down to the os uteri. As soon as this occurs the fœtus attempts to make its escape, and if it is strong it succeeds, but if the attempt fails it is repeated at the eighth month, and if the infant now succeeds in escaping from the womb, being exhausted by its previous effort, it is likely to die.

[2] Schroeder, from the measurements of 68 premature infants, gives the average biparietal diameter of the head as 8.83 cm. from the thirty-sixth to the fortieth week; 8.69 cm. from the thirty-second to the thirty-sixth week; 8.16 cm. from the twenty-eighth to the thirty-second week; showing that this diameter, a most important one, is relatively very large even early in fœtal life.

Tenth Month.—During the tenth month (thirty-sixth to fortieth week) the fœtus is developing from the condition just described, that is characteristic of the thirty-sixth week, into the infant at term, distinguished by all the features that indicate the arrival of the fœtus at maturity. It is during the last month of pregnancy that the physiology of the fœtus can be studied to the best advantage. It has now reached a large size and requires a considerable quantity of oxygen[1] for its blood and nourishment for its tissues, both of which it obtains from the maternal blood through the medium of the epithelial cells that form the outermost fœtal layer of the placenta. From the fact that the fœtus undoubtedly swallows considerable quantities of liquor amnii during the later months, at least, of pregnancy,[2] and because that liquor contains a small proportion of albumen,[3] some recent writers would have it that the fœtus derives its whole nourishment from the amniotic fluid, while the function of the placenta is confined to the oxygenation of the fœtal blood—a theory that has not yet found general acceptance, nor is it likely that it ever will. Another fact, however, in its favor is the secretion of the stomachic glands, which is going on during the latter period of intra-uterine life.[4] The urine, which is secreted in considerable quantity, and which is, as a rule, albuminous,[5] is voided freely into the amniotic cavity. The fœtus from time to time moves its limbs vigorously, and its heart beats from one hundred and twenty to one hundred and sixty times a minute.[6] It has been claimed that the sex of the child may be foretold by the rapidity of the fœtal heart-sounds, Prof. Wilson[7] of Louisville placing the dividing-line at one hundred and thirty-four—a rapidity greater than that indicating a female fœtus, one below a male. This is only so far correct as boys are, on the average, longer and heavier than girls. The rule may be said to be that the rapidity of the fœtal heart-beat is in inverse ratio to the length and weight of the fœtus.

The circulation of the fœtal blood has certain peculiarities that deserve consideration. Beginning at first by a very simple arrangement in a tubular heart and four vessels, two arteries, and two veins, which carry

[1] That the fœtus obtains oxygen from the maternal blood has been proved by (1) cutting off the blood-supply to the uterus, when the fœtus will die of asphyxia (Vesal, Seyl); (2) by the discovery by means of spectral analysis of oxyhæmoglobin in the umbilical vein of the cord (Zweifel).

[2] Zweifel: "Untersuchungen über das Meconium," *Arch. f. Gynäk.*, Bd. vii. 1875, p. 474.

[3] Anderson: *Am. Journ. Obstet.*, Aug., 1884.

[4] "Magensecretion des Fötus," Krukenberg, *Centrbl. f. Gynäk.*, No. 22, 1884.

[5] Ribbert: "Ueber Albuminurie des Neugeboren u. des Fötus," *Virch. Arch.*, Bd. xcviii. S. 527.

[6] The fœtal heart-sounds were first heard by Mayor, a surgeon of Geneva, in 1818, and first accurately described by Legumeau de Kergaradec, 1821.

[7] Parvin's *Obstetrics*, p. 192.

the blood to and from the umbilical vesicle, it soon assumes the characteristics that are most plainly to be seen in the stage of pregnancy under consideration. The blood that has been oxygenated in the terminal villi of the placental tufts is returned by veins of increasing size to the large branches of the umbilical vein that may be seen directly under the amnion on the fœtal surface of the placenta. These branches, converging, unite in the umbilical vein, which is carried by the cord to the fœtal body, which it enters at the umbilicus. Thence it runs along the anterior surface of the abdominal cavity to the under surface of the liver, where, giving off branches to the lobus quadratus, lobus Spigelii, and to the left lobe, it divides into two main trunks at the transverse fissure, the larger of which enters the portal vein, while the other empties into the ascending cava and is called the ductus venosus. Thus by far the greatest quantity of oxygenated blood that is returned to the fœtus from the placenta must first pass through the liver before entering the general circulation. The ascending cava conveys then to the right auricle a large proportion of arterial blood, but mixed with it is the venous blood from the lower extremities and the blood returned from the liver. But this great volume of blood having arrived at the right auricle, instead of descending into the right ventricle, and being carried thence to the lungs, which in their unexpanded condition could not contain it, is guided across the right auricle by the Eustachian valve, and enters the left auricle by means of an opening in the interauricular septum, the foramen ovale. From the left auricle the blood from the ascending cava enters the left ventricle, and is driven thence into the aorta, by which it is conveyed primarily to the upper extremity of the fœtus by the ascending branches of the arch of the aorta. Here

Fig. 160.

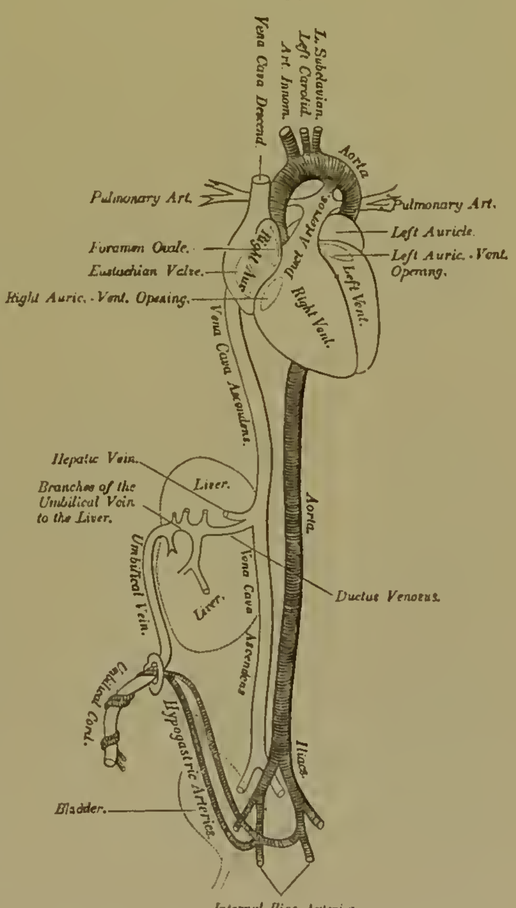


Diagram of the Fœtal Circulation (Flint).

may be seen an arrangement peculiar to fœtal life, by which the blood is diverted from the unused lungs and conveyed instead to the aorta. Just beyond the point at which these branches are given off there opens into the aorta a large branch from the pulmonary artery, the ductus arteriosus, which conveys the blood that enters the right auricle, and then the right ventricle, from the descending vena cava, only a small quantity of blood, sufficient for their nutrition, going to the lungs. Thus it will be seen that the aorta conveys a mixed blood, still further devitalized from the infusion of the venous blood from the head, neck, and upper extremities, to the trunk and lower extremities. It is by this arrangement that a greater quantity of arterial blood is conveyed to the brain, which develops so rapidly during intra-uterine life, and will have such important functions to perform immediately after birth. Following the blood-current down the aorta to the iliac arteries and then to their internal branches, two arteries, one from each branch, may be seen springing upward toward the umbilicus, whence they pass out of the body to form the two arteries of the umbilical cord. Within the body they are known as the hypogastric arteries. The two arteries of the cord carry to the placenta what is usually called venous blood, which in the terminal placental villi discharges into the maternal blood the effete products of the life-processes in the fœtus, and receives in return a fresh supply of oxygen and nutriment, and probably a fair share of the soluble salts of the blood, as well as any other substance, medicinal[1] or otherwise, that the maternal blood may contain in solution or possibly even in suspension. While the passage of matter from the maternal into the fœtal blood seems to occur so frequently, it would appear to be more difficult for substances, aside from the effete products of tissue-activity, to pass from fœtus to mother. There is reason to believe, however, that the poison of syphilis may take this course.[2] It has also been demonstrated that certain drugs, as strychnia, may pass from fœtus to mother.[3] The ease with which medicinal substances will pass from mother to fœtus has given rise to anxiety lest in the administration of powerful drugs to the mother the fœtus might be injuriously affected.[4] It is possible, of course, to harm the fœtus by administering poisonous substances to the mother, but it is extremely unlikely that the fœtus will be much affected unless the dose to the mother much exceeds the usual therapeutic limit. But, like the adult, the fœtus may become accus-

[1] Chloroform, carbonic oxide gas, salicylate of sodium, benzoate of sodium, atropia, strychnia, morphia, quinia, corrosive sublimate, iodide of potassium, ether, urea, the bile-salts, soluble salts of lead, tobacco, sulphindigolate of soda, the germs of many diseases, have all been known to pass from mother to fœtus.

[2] See p. 265 for the infection of the mother by syphilis in the fœtus.

[3] Schroeder: *Geburtshülfe*, 8th ed., p. 63.

[4] Parvin's *Obstetrics*, 148.

tomed to a drug, and be able finally to endure large quantities of it in the maternal blood.[1]

The temperature of the fœtus in utero is slightly higher than that of its mother. Priestley,[2] in experiments on rabbits and cats, found the temperature of the fœtus about one degree (Fahr.) higher than that of its mother; which seems natural enough if one considers the very great functional activity in the organs of the rapidly-growing fœtus, and the fact that the liquor amnii, although abstracting heat to some extent from the fœtal body, remains itself at a constant temperature equal at least to that of the maternal body. That the human fœtus also possesses a temperature higher than the maternal body-heat has been proven by taking the temperature *in ano* of a fœtus coming down during labor by the breech, and comparing it with the temperature of the vagina,[3] or by taking the temperature of infants immediately after birth.[4] In these cases the fœtal body is found warmer by 0.5° (C.) than the maternal body.

Of all the organs in the fœtal body, the *liver* seems the most active. How almost all the arterial blood from the placenta goes first to the liver has been noticed. The great quantity of meconium in the fœtal intestines—a substance composed mainly of bile-salts—attests the active secretory work of this organ, and to it too may be attributed the source of the large quantity of glycogen[5] found in fœtal tissues, especially the muscles, where this substance has work to perform the nature of which is not yet understood.

The Mature Fœtus.

There is no single sign, perhaps, that would enable one to declare a given fœtus to be fully mature, but the weight, measurements, and stage of development, taken together, will indicate with tolerable accuracy the length of time that the fœtus has remained in utero. By the two hundred and eightieth day a healthy fœtus should weigh about

[1] I was obliged not long ago to administer large doses of morphia daily for a period of some weeks to a patient who was suffering from general septicæmia in the seventh month of pregnancy. The fœtus continued to move actively in utero, and I could detect no change in the fœtal heart-sounds. The woman finally gave birth to a living infant.

[2] "Lumleian Lectures on the Pathology of Intra-uterine Death," rep. for *Brit. Med. Journ.*, 1887, p. 16.

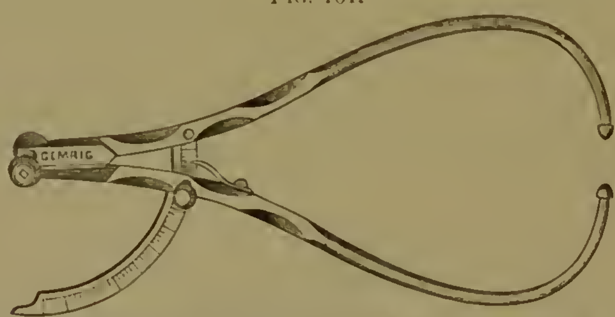
[3] Wurster: *Berl. klin. Wochenschr.*, 1869, No. 37, and *Beitr. z. Tocothermometrie*, *D. i.*, Zürich, 1870.

[4] See Baerensprung, *Müller's Arch.*, 1851; Schäfer, *D. i. Greifswald;* Andral, *Gaz. hébd.*, July, 1870; Schroeder, *Virch. Archiv*, Bd. xxxv. S. 261; and the *Lehrbuch*, 8th ed., 1884, p. 65, also, Alexeeff, *Arch. f. Gynäk.*, Bd. x. S. 141.

[5] Marchand: "Ueber das Glykogen in einigen fötalen Geweben," *Virch. Arch.*, Bd. c. S. 42.

$7\frac{1}{3}$–$7\frac{2}{3}$ lbs., according to the statistics of Lusk and Parvin; but in Europe the weight of the mature fœtus would seem to be somewhat less, for the statistics of Scanzoni, Ingerslev, Hecker, Fesser, and Bailly, including a very large number of observations, give a weight of less than seven pounds. Variations in weight at term between six and nine pounds[1] are by no means rare, and the range of possibility as to the weight of a mature fœtus is a very wide one. Thus Harris[2] tells of one infant that weighed but a pound, and of another, the child of the Nova Scotia Giantess, that weighed twenty-eight and three-fourths pounds. A decided departure, however, from the normal average would indicate, on the one hand, prematurity or a weak development; on the other, the prolongation of pregnancy, race peculiarities, the vigor or excessive size of the parents, especially the mother, or the preoccurrence of several pregnancies. Sex also influences the size of the infant, males being, on an average, larger than females. The length of a mature fœtus is 20–21 inches (51–53 cm.). The width across the shoulders (binacromial diameter) is about 12 cm. (4.75 in.); the dorso-sternal

FIG. 161.



A Convenient Instrument for Measuring the Diameters of the Fœtal Head (Martin's Pelvimeter).

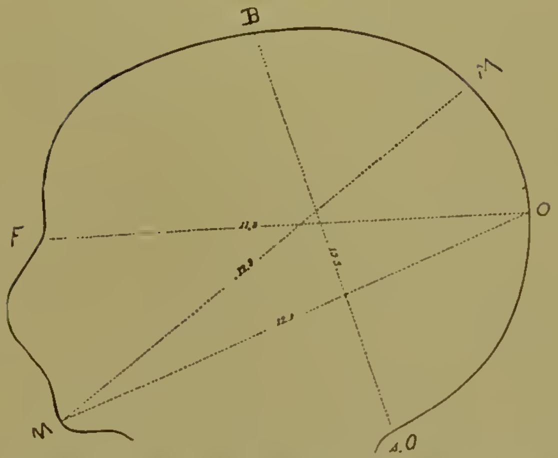
diameter is 9–9.5 cm. (3.5 in.); the biniliac, 9.5–10 cm. (4 in.). The length of the foot is about 8 cm.[3] The dimensions of the head are important, not only as a sign of the development of the fœtus, but from their important relation to the calibre of the parturient canal. The shape and the size of the fœtal head in utero immediately before labor begins, and before the occurrence of the moulding to the irregularities of outline that characterize the pelvic straits and cavity, may be learned from the observation of those infants that have been extracted after Cæsarean section.

[1] An infant of over nine pounds is not common, while heavier weights are progressively rarer. Out of 1000 infants, Dr. Parvin saw but one that weighed 11 pounds (Parvin's *Obstet.*, p. 138). Of 1156 infants born in the Maternity Hospital, the heaviest weighed 12 pounds.

[2] Note to Playfair's *Midwifery*.

[3] Negri says (*Ann. di. Ostet.*, May–June, 1885) that when the foot measures 8 cm. the fœtus is well developed and weighs about 3500 gms.

FIG. 162.



Shape and Diameters of a Fœtal Head before Labor begins (Budin).

The following dimensions of the fœtal head may be considered characteristic of the normally-developed infant directly after its expulsion from the uterus:

Bitemporal (B. T.) diameter, 8 cm.
Biparietal (B. P.) diameter, 9¼ cm.
Occipito-frontal (O. F.) diameter, 11¾ cm.
Occipito-mental (O. M.) diameter, 13 cm.
Maximum (M. M.) diameter, 13½ cm.
Suboccipito-bregmatic (S. O. B.) diameter, 9½ cm.
Trachelo-bregmatic (T. B.) diameter, 9½–10 cm.
Circumferences: O. F., 34½ cm.; S. O. B., 30; O. M., 37.

These dimensions are subject, however, to considerable modifications. Any of the causes that tend to increase the size of the infant as a whole will likewise influence the size of the head; but even with a normal body-weight and length the head may be so disproportionately large, without being diseased, as to present a most serious complication of labor.[1]

Another valuable sign of maturity in the fœtus is the appearance and extent of certain centres of ossification.[2] In the centre of the lower epiphysis of the femur may be found at birth a spot of ossification measuring 5 mm. in diameter, while a similar but smaller spot is just appearing in the upper epiphysis of the tibia. The centre of

[1] Two exceedingly difficult forceps deliveries that recently occurred in the writer's practice were due to this cause. The head measurements were, in one case, B. T., 8½; B. P., 9½; O. F., 13; O. M., 14; S. O. B., 9½. Circumferences: O. F., 38½; O. M., 41¼. In the other, B. T., 8¾; B. P., 10; O. F., 13; O. M., 15½; S. O. B., 9¾. Circumferences: O. F., 38; O. M., 43. The body-weight of the first child was 7½ lbs., that of the second, 8½ lbs.

[2] See Rossié: *Am. Journ. of Obstet.*, 1886, p. 18.

ossification in the astragalus is to be found without difficulty, for it first appears at the seventh month of intra-uterine life. The centre of ossification in the cuboid bone is at birth beginning to make its appearance. The ossified spot in the upper epiphysis of the humerus only appears some months after birth.

The general appearance of a newborn infant is of value as indicating whether or not the fœtus had reached maturity before its expulsion from the uterus. A healthy infant at term looks stout and well-nourished, owing to a liberal supply of subcutaneous fat. The face is plump and is free from lanugo; miliaria are to be seen about the tip of the nose, but are not nearly so evident as they were in the tenth, and especially the ninth, month of intra-uterine existence (Küstner). The eyes are usually opened, the limbs move vigorously, and the child will seize with its lips the nipple when presented to it, and will suck with energy. The vernix caseosa is abundant only on the back of the child and on the flexor surface of the limbs. The nails project beyond the finger-tips; the cartilage of the ears and nose feels firm; eyebrows and eyelashes are well developed; the hairs of the scalp are about an inch long; the bones of the head are hard and lie close together. The breasts in both sexes are large, and usually a thin fluid can be squeezed out of them. In boys the testicles are usually to be felt in the scrotum, although the tunica vaginalis is not yet closed. In girls the labia majora are usually approximated, although occasionally the minora project between.

The Determination of Sex.—In all countries the number of male children born exceeds the number of females, the average proportion being 106–100; but, as more boys die than girls, by the time puberty is reached the sexes are about equal in number. This normal proportion is, however, in modern times much disturbed by the migratory tendencies affecting chiefly the male populations of old and long-settled countries. The law that governs the production of sex has long been a subject of discussion and speculation. The Hippocratic doctrine that the right ovary produced boys, and the left girls, was for centuries accepted by the majority as the truth, and upon this belief was founded the precept that women who desired male offspring should lie during coition upon the right side, while those who wished daughters must lie upon the left side. By experiments upon animals, by the observation of women in whom one ovary was destroyed by disease, and by a more complete knowledge of the mechanism of impregnation, the long-accepted teaching of Hippocrates was disproved, although not until comparatively recent times. At present it is yet undecided whether the question of sex is decided before impregnation occurs—that is, whether certain spermatic particles or ovules are predestined to produce males, while others will produce females; whether the sex is impressed upon the ovule at the moment of conception; or whether the embryo is possessed of the elements of both sexes until one or the other acquires a preponderating influence owing to causes which may be operative during the early part of pregnancy. The first theory receives its chief support from the fact that unioval twins are invariably of the same sex, which looks as though the ovule was predestined in the ovary to the formation of one or the other sex. The last theory is based upon the study of plants and lower animals, in which the sex is only determined at some time after conception by the influence of nourishment; over-feeding being found to produce females, under-feeding to produce males. It is even possible in the case of certain animals to alter the sex, or at least to produce hermaphrodites, even after the sexual organs have begun to be differentiated.[1] This theory is further strengthened by the fact that in the human embryo the elements of both sexes are always present apparently in equal force during the early part of embryonal life. The belief that the sex of a human embryo is impressed upon it at the moment of conception rests upon the fact that in certain conditions of nourishment or sexual vigor in one or the other parent one sex will preponderate, while under opposite circumstances the other sex will most frequently be produced.[2]

Disregarding the time at which sex is determined, the most diverse conditions have been called upon to explain apparent departures from the normal numerical relation of the sexes at birth. Illegitimacy,[3] age of the parents,[4] conception at certain periods after menstruation,[5] deformities in the female pelvis,[6] the state of nourishment or sexual vigor of the parents,[7] the tendency of each sex to produce the opposite or the reverse,[8] the tendency to produce that sex which is most needed to per-

[1] In the case of the larvæ of bees from impregnated eggs, when the female genital organs have begun to appear, if the nourishment is very insufficient, instead of becoming female workers these animals will actually develop into true hermaphrodites, with the organs of both sexes (Fürst).

[2] Thury (*Zeitschr. f. w. Zoologie*, 1863, Bd. xiii. S. 541) found in twenty-nine experiments upon cattle that in every case, if connection occurred at the beginning of heat, females were produced; if at the end, males.

[3] Fürst (*Arch. f. Gyn.*, Bd. xxviii. S. 19) says that in illegitimate births the males fall below the average (based upon 807,332 cases). This coincides with the experience in the Maternity Hospital in more than 1000 cases.

[4] See Hofacker: *Ueber die Eigensch. welche sich von den Eltern auf die Nachk. vererben*, 1828; Sadler, *Law of Population*, London, 1830; Hecker, *Arch. f. Gyn.*, Bd. vii. S. 448; Bidder, *Zeitschr. f. Geburtsh.*, Bd. ii. S. 358; Ahlfeld, *Arch. f. Gyn.*, Bd. ix. S. 448; Wall, "The Causation of Sex," *London Lancet*, 1887, i., pp. 261, 307.

[5] Thury, *loc. cit.*; Coste, *Comptes rendus*, 1865; Schroeder, *Lehrbuch*, 8te Aufl., 1884, S. 33; Fürst, "Knaben Ueberschuss nach Conception zur Zeit der postmenstruellen Anämie," *Arch. f. Gyn.*, Bd. xxviii. S. 18.

[6] Olshausen: *Klinische Beiträge*, Halle, 1884; Linden, "Hat das enge Becken einen Einfluss auf die Entstehung des Geschlechts?" *Dis. Inaug.*, Marburg, 1884; R. Dohrn, *Zeitsch. f. Geburtsh. u. Gyn.*, Bd. xiv. S. 80.

[7] See Fürst, *loc. cit.*, and Schroeder, *op. cit.*, S. 33.

[8] See Fürst, *loc. cit.*

petuate the species,[1] the season of the year,[2] climate and altitude,[3] and the degeneration of a race, as during the degeneration of imperial Rome,[4]—have all been advanced as reasons for apparent excess in the number of male or female births as the case might have been. All these theories, however, have been found either false or inadequate upon further investigation. The only explanation that appeals strongly to the writer's reason is that the individual stronger in mental, physical, and sexual attributes will impress upon the ovule at the moment of impregnation that individual's sex. Personal observation has tended to confirm this view, most markedly in three instances: A gentleman having arrived at middle age, a widower, remarried, his wife being a young and vigorous woman. The children resulting from this union were four in number, all girls. In another case a young man of weakly constitution, threatened with phthisis, married a young woman the perfect type of vigorous womanhood; they had three children, all girls. Again, a gentleman now of mature years, but possessing even yet the most extraordinary mental and physical power, married when young: his children, some five or six in number, were all boys. A perfectly satisfactory explanation of the determination of sex, however, will be difficult to obtain, while the production of the sexes at will must always be an impossibility.

Multiple Fœtation.—It is the rule that but one fœtus at a time is developed within the uterus of a human female. Once in 89 pregnancies,[5] however, two fœtuses will be developed simultaneously in the same uterus, so that twins are not of uncommon occurrence. Triplets will be found once out of 7900, quadruplets once out of 371,126 births. Quintuplets are extremely rare. Multiple fœtation may be the result (1) of the impregnation of a single ovum that contains two or more germinal vesicles, or in which the formative material of the area germinativa divides;[6] (2) of the impregnation of two or more ova which were contained either in one Graafian follicle or in separate follicles, the latter being situated either in one or both ovaries.

If the multiple fœtation is the result of the impregnation of a single ovum, there will be but one chorion and one decidua reflexa, although each fœtus will be enclosed in its own amnion.[7] In these cases the sex

[1] Düsing: *Die Regulirung des Geschlechtsverhältnisses bei der Vermehrung der Menschen, Thiere, u. Pflanzen*, Jena, 1884.

[2] According to Düsing (*loc. cit.*), women impregnated in summer give birth to fewer boys than those impregnated in winter (conclusions based on more than ten and a half million births).

[3] Ploss found in Saxony that up to 2000 feet the greater the altitude the larger was the number of male births (at 2000 ft., 107.8–100).

[4] Darwin's *Collected Works*.

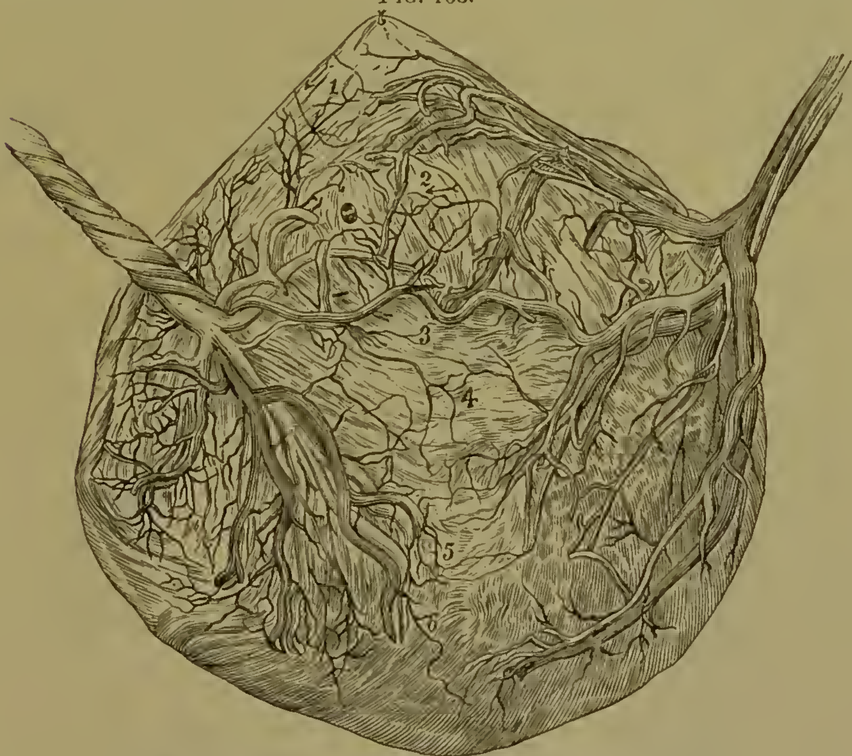
[5] Conclusion of Veit, based on more than thirteen million births.

[6] Ahlfeld: *Arch. f. Gyn.*, Bd. ix. S. 196.

[7] Occasionally two fœtuses are found in a single amniotic cavity, which is to be

of the fœtuses will be the same. The placentæ will usually be found intimately united when expelled at term, presenting extensive arterial and venous anastomoses—a condition that may give rise to the deformity of one of the twins known as acardia (see p. 300, this section). But in the early stages of development each placenta, even in unioval twins,

FIG. 163.



Twin Placenta, showing extensive anastomosis of the blood-vessels.

is separate. When the embryos are derived each from a separate ovum, there should be separate deciduæ reflexæ, chorions, and placentæ. Occasionally, however, when the ova are implanted close together, the placentæ may join one another, there may be but one decidua reflexa, and it may be difficult to detect the double layer of chorion that should separate the two ova.

Although twins are not infrequently born, the condition should be regarded as pathological in its influence, at least, upon the fœtus. From statistics collected by Schatz,[1] it appears that in twins from different ova one would be born dead in every 23 cases, while from the same ovum the death-rate would be 1 : 6. One fœtus will perhaps

explained (1) by the atrophy and absorption of the contiguous amniotic walls; (2) by rupture of the amnion in the later months from the vigorous movements of the fœtus; or (3) by the development of but a single amnion from the very beginning (Myschkin, *Virch. Arch.*, cviii. S. 133, 146).

[1] *Arch. f. Gyn.*, Bd. xxix. S. 438.

outstrip its fellow in growth, and divert the greater part of the nourishment from the mother to itself, thus growing rapidly and encroaching so upon the room that should belong to the weaker fœtus that the latter is killed, and finally pressed flat against the uterine wall (fœtus papyraceus). Hydramnion is also very common in twin pregnancies, and occasionally one fœtus is converted into an acardiac monster. If the fœtuses of a twin pregnancy escape the dangers of intra-uterine life, there are many perilous complications awaiting them in labor. Should one fœtus die during pregnancy, it is usually retained until term, when the living and dead children are cast off together, widely differing in appearance and development;[1] or else one ovum may be aborted at an

Fig. 164.

Twins seen on Section of a Woman who died suddenly from Hemorrhage in the last week of Pregnancy (Sippel): *a*, tear in chorion; *bb*, bladder and vaginal vault; *cc*, uterine walls, folded back; *d*, fundus uteri.

early period of pregnancy, while the other goes on developing till term.[2]

Even though both children have been retained in utero an equal length of time, there is usually a marked difference in their length and

[1] Schultze: *Volkm. Samml. klin. Vorträge*, No. 34.

[2] Sirois: *L'Union médicale du Canada*, July, 1887; and Warren: *Am. Journ. Obstet.*, 1887.

weight, especially if they have resided in one ovum.[1] In cases of uterus duplex, fœtuses of different ages have been found developing in the two divisions of the uterus. Fordyce Barker reports a case of delivery of two mature children from a woman with a double uterus, one male, the other female, at an interval of two months.[2] Upon such cases, and also upon the fact that of twins in negresses rarely one is light and the other dark, showing of course different paternity, has been based the theory of superfœtation; but as there is no clear proof as yet of the occurrence of ovulation during pregnancy, the possibility of the impregnation of ovules which escaped from their Graafian follicles at rather wide intervals of time, say weeks or months, must still remain in doubt.[3]

THE DEVELOPMENT, THE ANOMALIES, AND THE DISEASES OF THE FŒTAL APPENDAGES.

The fœtal appendages play such an important part in the healthy development of the fœtus itself, and their diseases can so seriously affect the growth and the life of the fœtus, that the study of their development, anomalies, and diseases is necessary to a clear understanding of fœtal pathology. First will be considered the development and diseases of the fœtal appendages springing directly from the embryo—namely, the amnion, the chorion, the allantois, and the placenta; lastly, the deciduæ, the maternal envelope of the fœtus.

The Amnion.

It has been seen that, after segmentation has occurred, and after the interior of the ovum has become reduced to a granular mass, around which is a membrane composed of a single layer of cells, at a certain point in this membrane there appears a thickening, a heaping-up of the cells. Finally, this small mass of cells resolves itself into two layers (epi- and hypoblast), and between these two appears another layer of cells (mesoblast).

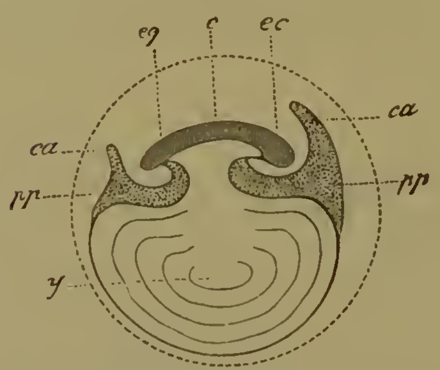
The outer layer, the epiblast, sends a prolongation around the whole interior surface of the ovum, and this receives a reinforcement from the middle layer of cells, or the mesoblast. As now the embryo begins to assume a definite shape and the lateral walls begin to fold in toward one another, and the caudal extremity approaches a little to the cephalic end of the embryo, giving it the arched back so characteristic of the

[1] Schatz: *loc. cit.* [2] See Lusk: *op. cit.*, p. 233, ed. 1886.

[3] For some interesting observations which would seem to indicate the possibility, at least, of ovulation during pregnancy, see "Ovulation during Pregnancy," Christopher, *Am. Journ. Obstet.*, 1886, p. 457.

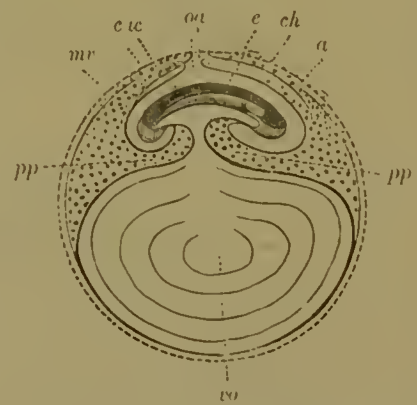
very young embryo, the outer layer of cells, forming a membrane continuous with the outer covering of the embryo, instead of simply being carried forward to meet in the median line in front, sends reduplications backward over the dorsal aspect of the embryo which shortly meet and join one another. Thus there are two cavities formed—one within the membrane thus doubled back upon itself, the other between the inner (the true amnion) of the two layers of membrane and the outer covering of the embryo. The latter is the true amniotic cavity, which is

Fig. 165.



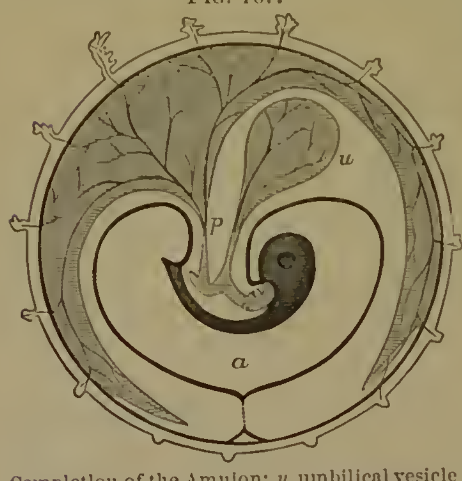
e, embryo; *ec*, cephalic extremity; *eg*, caudal extremity; *ca*, amniotic hood; *pp*, pleuroperitoneal cavity; *y*, umbilical vesicle.

Fig. 166.



e, embryo; *a*, amnion; *oa*, amniotic umbilicus; *cac*, amnio-chorional cavity; *pp*, pleuroperitoneal cavity; *ch*, chorion; *mv*, vitelline membrane; *vo*, umbilical vesicle.

Fig. 167.



Completion of the Amnion: *u*, umbilical vesicle; *p*, pedicle of the allantois; *a*, amniotic cavity.

gradually more and more distended by the accumulation of fluid until the membrane which contains it is pushed out on all sides, uniting in front around the umbilical cord, and coming in contact throughout the whole extent of the ovum with the outer membrane (true chorion) already described, to which it becomes loosely united by a gelatinous substance, the tunica media of Bischoff.

The Fully-developed Amnion.—The amnion forms the innermost of the membranes that surround the fœtus at term. It is continuous with the fœtal epidermis at the umbilicus, and forms a complete sheath for the umbilical cord, and also covers the fœtal face of the placenta. In its structure it consists of a single layer of flat endothelial cells turned toward the cavity of the amnion, and externally of a layer of young connective tissue, in which may be seen long spindle- or star-shaped cells with long nuclei imbedded in a fibrous substance (Schroeder). The regular disposition of the inner layer of endothelial cells, however, is disturbed at certain points of the amnion lying over the placenta, where there may be seen numbers of cells heaped together, forming a little villus-like projection. There are, normally, no blood-vessels in the amnion, at least in its later stages of development; their possible occurrence, however, will be referred to later.

THE LIQUOR AMNII.—It is the physiological function of the amniotic membrane to furnish a fluid medium, the liquor amnii, which distends the uterine walls and allows the fœtus some freedom of movement, and by its density, approaching the specific gravity of the fœtus, robs these movements of much muscular effort. It acts as an additional protection to the fœtus from external violence, pressure, and changes of temperature; it receives the urine secreted in the latter part of fœtal life; and perhaps has some little part in the nourishment of the fœtus, or at least in supplying the fœtal tissues with that excess of water which they have been shown to possess during intra-uterine life.[1] That the fœtus actually swallows considerable quantities of liquor amnii admits of no doubt, for not only have lanugo and epidermis-scales been found in the meconium,[2] but also particles of colored matter which had entered the amniotic fluid from the maternal structures (Zuntz). It is not likely, however, that the liquor amnii plays an important part in the nourishment of the fœtus, as claimed by v. Ott and others; for if it did the birth of well-nourished children with a breach of continuity in the upper part of the alimentary tract from the mouth to the small intestines would be inexplicable.

The Composition of the Liquor Amnii.—The amniotic fluid is usually clear, occasionally, however, opaque, whitish, greenish, or a dark brown from the presence of meconium, or of a reddish color when the fœtus is macerated. The specific gravity varies in the most remarkable manner—from 1002–1028 (Schroeder), being usually, however, about 1007–1011. Its reaction is weakly alkaline. It contains salts, urea, carbonate of ammonia, kreatinin, albumen, and, besides lanugo, sebaceous matter, epidermis, scales from the fœtal skin, and epithelium from the bladder and kidneys. The *quantity* of the liquor amnii differs at different periods of pregnancy: in the early stages it develops with great rapidity, and at the middle of pregnancy has reached its maximum of about 1–1.5 kilograms (Landois). From this time it diminishes in amount, until at the end of pregnancy its average quantity is 680 grams.[3]

The Origin of the Liquor Amnii.—The origin of the liquor amnii

[1] Preyer: *Physiologie des Embryos.*

[2] Zweifel: "Untersuchungen über das Meconium," *Arch. f. Gyn.*, Bd. vii. 474.

[3] Fehling: *Arch. f. Gyn.*, Bd. xiv. S. 221.

has been attributed to a maternal source, or it has been said to be derived entirely from the fœtus, or, again, it is claimed that both the mother and fœtus contribute to its formation. The last view is doubtless correct. The maternal origin[1] of the amniotic fluid has been demonstrated by Zuntz, who injected sodium sulphindigolate into the veins of pregnant rabbits, and found a blue coloration of the amniotic fluid, although there was no coloring matter in the kidneys of the fœtus. As further evidence might be cited the fact that there are cases in which the embryo is destroyed very early, but in which an amount of amniotic fluid may be found corresponding, not to the age of the embryo, but to that of the ovum. And, moreover, it is not unusual to find hydramnion associated with some other serous effusion in the mother.[2]

That the fœtus also contributes to the formation of liquor amnii is demonstrated by the fact that the excretion of urine during the latter part of fœtal life reaches a considerable amount. Thus, more than three pints of urine have been found retained in the fœtal bladder.[3]

Gusserow[4] has injected benzoic acid into the mother, and recovered it as hippuric acid in the liquor amnii—a proof that it had passed through the kidneys of the fœtus; and Wiener has found sodium sulphindigolate in the fœtal kidneys and bladder after it had been injected into the maternal tissues. The constant presence of urea[5] in the amniotic fluid, at least after the sixth week, is an additional proof, if one were needed, of the renal activity of the fœtus. It is probable also that the vasa propria, discovered by Jungbluth[6] in the early life of the embryo lying close under the amnion, have something to do with the production of the amniotic fluid in the earlier periods of pregnancy. Prochownik[7] claimed that it was the skin of the fœtus that secreted the amniotic fluid during the early months of gestation; and there has since appeared corroborative evidence in regard to this particular function of the fœtal skin. There have been cases of hydramnion associated with morbid conditions of the skin, notably one instance observed by Budin[8] where the skin of the fœtus was the seat of extensive nævi.

[1] Ahlfeld ("Ueber die Genese des Fruchtwassers," *Arch. f. Gyn.*, Bd. xiii. pp. 160–241) gives an ingenious explanation of the manner in which the maternal structures take part in the formation of the liquor amnii: As the uterus develops by an eccentric hypertrophy, the pressure within the uterine cavity becomes less than that of the abdominal cavity, and consequently there is a disposition for the serum of the maternal blood to exude into the amniotic cavity. As Phillips (*Edin. Med. Journ.*, March, 1887, p. 811) remarks, however, the case of hydramnion in extra-uterine pregnancy (*Arch. f. Gyn.*, Bd. xxii. p. 57) reported by Teuffel would seem to invalidate this theory.

[2] *Pflüger's Arch.*, Bd. xvi. S. 548; and Wiener, *Arch. f. Gyn.*, Bd. xvii. S. 24.

[3] Lefour: *Arch. de Tocol.*, June 30, 1887.

[4] *Arch. f. Gyn.*, xiii. S. 56.

[5] Prochownik: *Arch. f. Gyn.*, Bd. xi. S. 304–561.

[6] *Beitr. zur Lehre v. Fruchtwasser*, Inaug. Dissert., Bonn, 1869; *Virchow's Archiv*, Bd. xlviii. S. 523; *Arch. f. Gyn.*, Bd. iv. S. 554.

[7] *Loc. cit.*

[8] Tarnier et Budin, *loc. cit.*, p. 279.

Thus it appears that the amniotic fluid is derived from a fœtal as well as a maternal source, but as to the relative importance of the fœtal or maternal supply of liquor amnii at different periods of pregnancy, we are still in doubt.

Abnormalities of the Amnion.—One must be struck with the close analogy between the pathology of the amnion and that of the serous membranes generally. There is the same liability to changes of secretion, to inflammation with a plastic exudate, and the formation of bands of adhesion over a more or less extensive surface. The function of the amnion, however, and its close relation to the embryo and fœtus, give rise, in case of disease, to symptoms and results peculiar to itself.

Abnormalities of Secretion.—The quantity of liquor amnii varies, at term, between one and two pints (Gusserow). Occasionally, however, the quantity of fluid is very much below the normal—so much so in some cases as to seriously interfere with the growth of the fœtus and to determine its premature expulsion.[1] Schatz[2] reports a case in which there were ulcers on the inner surface of the knees and malleoli of a fœtus from constant friction due to a deficient quantity of liquor amnii, and many curious deformities of the fœtus may be traced to the same cause.[3] This condition goes under the name of *oligo-hydramnios.* More frequently the quantity of the liquor amnii becomes abnormally increased—a condition known as polyhydramnion, hydro-amnion, dropsy of the amnion, or, more commonly, hydramnion.

Hydramnion.—It has been already stated that the normal quantity of liquor amnii at the end of pregnancy is one to two pints. Should this quantity be much exceeded, the condition of hydramnion would exist. A slight excess is no doubt frequent, but would usually pass unnoticed, while an accumulation of fluid amounting to two quarts or more, which might perhaps inconvenience a woman, is not very common. It is difficult, therefore, to decide as to the relative frequency of hydramnion. Charpentier states that it occurs in 1 : 100 or 1 : 150 pregnancies—an estimate probably too low for the minor grades of the affection, but far too high for those more decided cases in which the accumulation of fluid is large enough to give rise to well-marked symptoms. In the majority of cases the fluid collects gradually, but steadily, until at the end of pregnancy it may reach the enormous quantity of six gallons or more.[4] Occasionally, however, the fluid accumulates very rapidly, giving rise, from the sudden distension of the uterus, to symptoms of a grave character. This is known as acute hydramnion.

The Etiology of Hydramnion.—The wide diversity of opinion in regard to the origin of hydramnion indicates plainly enough how

[1] *London Lancet*, 1886, ii. p. 383.
[2] *Arch. f. Gyn.*, Bd. xix. S. 329.
[3] See Tarnier et Budin, p. 294.
[4] Wilson: *Am. Journ. Obstet.*, Jan., 1887, p. 22.

indefinite is, as yet, our knowledge of the subject. In studying the source of hydramnion it is necessary to return to the study of the origin of the liquor amnii itself. The theories that at present prevail in regard to the formation of an excessive quantity of amniotic fluid may be thus classified: It may be due to (*A*) an over-secretion of liquor amnii, or to (*B*) a deficient absorption of the liquor amnii.

A. The excessive collection of fluid may be derived from (I.) a maternal source, (II.) a fœtal source, or (III.) both fœtus and mother may contribute to its production.

I. The hydramnion may have a maternal origin. That the serum of the maternal blood contributes to the formation of the liquor amnii has already been demonstrated; that it occasionally exudes in abnormally large quantities into the amniotic cavity is extremely probable. Thus in cases of hydramnion associated with serous effusions elsewhere in the mother's body the excess of liquor amnii is derived probably from a maternal source. Fehling,[1] who still adheres to his opinion that the liquor amnii is altogether a maternal production, says that "the thinner the maternal blood the greater is the quantity of liquor amnii." It would be well, therefore, to examine the blood of a patient who was affected with hydramnion, in order to detect a possible exaggeration of the usual hydræmia of pregnancy.

II. The hydramnion may originate entirely from fœtal structures. This supposition will explain by far the larger number of cases that admit of an explanation at all, for it must be remembered that hydramnion will often occur (44 per cent. of all cases—Bar) without a demonstrable cause in either mother or fœtus. The production of hydramnion being traced to the fœtus, it may be due to (*a*) abnormalities in the blood-vessels of the cord or of those directly under the amnion where it covers the placenta (persistence of the vasa propria of Jungbluth); (*b*) to an excessive urinary secretion; (*c*) to an abnormally great excretion from the fœtal skin.

(*a*) The vasa propria of Jungbluth, normally present in the early stage of embryonal development, have been found at term in cases of hydramnion,[2] and the production of an excessive quantity of liquor amnii has been attributed to their persistence. It is more probable, however, that the existence of these vessels is purely secondary, and that although the serum of the fœtal blood does exude from them into the amniotic cavity, their presence is due to an increased blood-pressure in the umbilical vein.[3] That increased internal pressure within the

[1] *Arch. f. Gyn.*, Bd. xxviii. S. 454.

[2] Levison: *Arch. f. Gyn.*, Bd. ix. S. 517; Lebedjew: *Traité prat. des Acc.*, Charpentier, 1883, pp. 886, 890.

[3] Winckler denies the existence of a capillary system of blood-vessels under the amnion, and attributes hydramnion to the presence of a capillary lymphatic system in the cell-layer of the chorion.

umbilical vein will give rise to a transudation through the amnion has been abundantly proved by Sallinger,[1] who found that the amount of fluid that would transude depended upon the strength of the pressure and the size of the cord. It may be generally stated, therefore, that any condition of the fœtus that will raise the blood-pressure in the umbilical vein, thus increasing the blood-pressure in the placenta, may give rise to hydramnion. This happens in those cirrhotic livers so common in syphilitic children, as may readily be imagined if one recalls the course of the umbilical vein after it enters the umbilicus. There are many other conditions having the same effect—a cord abnormally twisted, velamentous insertion of the cord (exposing the vein to external pressure), stenosis of the umbilical vein, obstruction of the ductus Botalli,[2] tumors of the placenta, tumors of the fœtus (interfering with its circulation), valvular defects of the heart,[3] etc.

(*b*) Excessive excretion of urine as a cause of hydramnion. The action of the fœtal kidneys in the production of hydramnion can best be demonstrated in cases of unioval twins,[4] in one of which it is so common to find a dropsical amnion, while the other one presents usually the opposite condition, oligo-hydramnion. The history of these cases is that one fœtus outstrips the other in growth, and thus, acquiring a preponderating influence in the placenta which is common to both, its heart takes on an hypertrophy to enable it to carry on the greater part of the placental circulation. The hypertrophied heart produces in its turn hypertrophy of the kidneys, and determines their increased secretion. The increased blood-pressure also determines an increased activity of the excretion from the skin, and thus in a twofold manner helps to increase the quantity of liquor amnii.

(*c*) The fœtal skin is a source of hydramnion. It can readily be understood how an increased blood-supply from an hypertrophied heart can stimulate the fœtal skin to over-action. There are, however, more direct proofs of the part that the skin may play in the production of hydramnion. Budin[5] has described a case of hydramnion associated with extensive nævi, and another in which the skin was thickened and thrown into folds. Steinwirker[6] has recorded a case of hydramnios with "elephantiasis congenita cystica."

Finally, it is not improbable that the amnion itself can take an *active* part in the over-production of liquor amnii—that, in other words, the amnion may be affected by acute inflammation, amniotitis, followed by an increased serous exudation. This supposition would explain those

[1] *Ueber Hydramn. im Zusamm. mit der Entstehung des Fruchtw.*, D. I., Zürich, 1875.

[2] Nieberding: "Zur Genese des Hydramnion," *Arch. f. Gyn.*, Bd. xx. S. 275.

[3] Cordell: *Tr. Med. and Chirurg. Fac. Maryland*, 1884, p. 218.

[4] Schatz: *Arch. f. Gynäk.*, Bd. xix. S. 329; Werth, *Ibid.*, Bd. xx. 353; Sallinger, *loc. cit.*

[5] *Loc. cit.*

[6] *Loc. cit.*

cases in which a blow or a kick[1] on the abdomen of a pregnant woman is followed by the development of hydramnion and the formation of adhesions between the fœtus and the amnion. To amniotitis has also been attributed the development of acute hydramnion. Werth's[2] theory also deserves some consideration before leaving the study of the fœtal origin of hydramnion. This author believes that an hypertrophied placenta can absorb more fluid from the maternal blood than is required for the fœtal economy; that the struggle to get rid of this excess of fluid brings about that hypertrophy of the heart and kidneys to which reference has already been made as occurring especially in one of unioval twins.

III. Both fœtus and mother may contribute to the production of an excess of liquor amnii. This proposition has already been demonstrated in showing the possible derivation of the liquor amnii from both mother and fœtus. The cause of the hydramnion, however, will most frequently be found in the fœtus, while the combined action of both mother and fœtus in a single case will be rare, but may occur, as in certain cases of syphilis in which have been found combined dropsy of the mother and fœtus associated with hydramnion.[3]

B. Hydramnion may be due to a deficient absorption of liquor amnii: Tarnier believes that the production of liquor amnii being normal, but its absorption deficient, hydramnion will result. Thus he would explain the cases of hydramnion associated with nephritis and serous effusions in the mother.

It has been proven that the fœtus swallows the liquor amnii in considerable quantities, and it is possible that the skin absorbs some of it. Whether the cessation of these two functions would result in hydramnion is as yet uncertain.

Symptoms and Diagnosis.—The symptoms of hydramnion are very like those of other abdominal cystic tumors. There is, however, the history of pregnancy; the tumor can usually be defined as the uterus, very much larger than usual for the date that pregnancy may have reached; and, except in extreme cases, it is possible to detect the fœtal heart-sounds or to practise ballottement. As the uterus becomes more and more distended it gives rise, by its increased size, to pressure symptoms in the abdomen and thorax, although it is astonishing to what size the uterus may attain while the patient remains tolerably comfortable. This is not the case, however, when the liquid is rapidly effused, as in cases of acute hydramnion. Here the most serious symptoms may manifest themselves. The woman suffers intense pain from the sudden distension of the uterus. Her breathing becomes labored, and com-

[1] *Tr. Obstet. Soc. of Baltimore*, meeting Feb. 9, 1887.
[2] Werth: *loc. cit.*
[3] Meissner and Hufeland, quoted by Wilson, *Am. Journ. Obstet.*, 1887, p. 13.

plete orthopnœa is developed; her face is cyanosed, and bears an anxious expression; constant and distressing vomiting appears; and there is fever.[1] The detection of hydramnion is not always easy, and may be practically impossible. It may be confused with pregnancy, associated with ascites, or with a cystic tumor of the ovary or broad ligament, or with an ordinary twin pregnancy; or the fact that the woman is pregnant may be entirely overlooked—a not uncommon mistake that has frequently led to the tapping of the pregnant uterus;[2] this procedure, however, would appear to be harmless. Finally, it might be possible to mistake the enlarged bladder associated with a retroflexed gravid uterus for a case of hydramnion (Tarnier). When the dropsy of the amnion has not reached an excessive degree, the distinction between it and ascites with pregnancy may be made by mapping out the uterine wall and detecting resonance along the flanks in the dorsal decubitus; and an ovarian cyst may be excluded by the absence of two tumors of different consistency and shape. A twin pregnancy without hydramnion will present, on external palpation, an enlarged uterus, offering firm but irregular resistance from its solid contents. In extreme distension of the uterus, which in bad cases seems only limited by the utmost capacity of the abdomen, a definite diagnosis becomes impossible: in such cases it might be advisable to resort to an exploratory abdominal section,[3] which has now become an operation of such slight danger.

Treatment.—If the fluid should accumulate in such great quantity or so rapidly as to produce alarming symptoms in the woman, its evacuation would naturally be indicated. This is best accomplished by the natural passage; that is, by rupturing the membranes through the cervix and allowing the liquor amnii to escape. By this method, unfortunately, labor is induced, and if the child has not become viable its destruction is a necessary consequence. And, moreover, the sudden gush of liquor amnii from the uterus may induce syncope by the rapid removal of the intra-abdominal pressure. It has, therefore, been proposed (Guillemet, Schatz) that the uterus be tapped through the abdominal walls, and a moderate quantity of liquor amnii be removed from time to time, thus preserving the life of the fœtus. As, however, the fœtus in cases of hydramnion is often deformed or diseased, and usually dies shortly after birth, its life deserves little consideration in comparison with the additional risk that is undoubtedly entailed upon the mother by puncturing the abdominal and uterine wall. It is especially

[1] See Charpentier, *Traité pratique des Accouchements.*

[2] Cases reported by Scarpa, Camper, Noël, Desmarais, Schatz, Tillaud, Chiara, Kidd, etc., not followed by the slightest bad results.

[3] Successfully performed in a case of extreme distension of the abdomen from hydramnion by Wilson, *loc. cit.*

in acute hydramnion, as Charpentier insists, that puncture of the membranes will be called for, irrespective of the age or condition of the fœtus.

Special instruments have been devised for the perforation of the membranes, and it has been suggested that the puncture be made at a point far within the uterine cavity, and thus removed from the external os, so that the liquor amnii may trickle slowly down between the membranes and the uterine walls, and the disadvantages of a sudden escape of the fluid be thus avoided. It is doubtful, however, if any better or more convenient appliance can be found than a stiff quill toothpick or a match sharpened at one end. The hand that is to use this simple instrument may be introduced into the vagina, so as to form a quite efficient plug, by means of which the operator may regulate at will the escape of liquor amnii. With this precaution it is immaterial whether the membranes be perforated during a pain or not.

Formation of Amniotic Bands.—Early in embryonal life, in case the amnion is not lifted away from the newly-forming skin of the embryo owing to an insufficient secretion of amniotic fluid, adhesions may form between the skin and the amnion, and, as the amniotic cavity becomes distended, the adhesive material is stretched, so that it finally forms bands of greater or less length or thickness, either connecting the fœtus with the amnion or with one or other or both ends detached, floating more or less free in the liquor amnii. The composition of these bands closely resembles that of the plastic material thrown out in inflammations of the serous membranes generally. They are not provided with blood-vessels. The exudation of this plastic material from the amnion has as a result the formation occasionally of extensive adhesions between the fœtus and the amnion, resulting often in grave deformities, as eventration or anencephalus, by preventing the proper arching over of the body-cavities by the fœtal skin. The formation of adhesive bands, moreover, is most frequently followed by intra-uterine amputations, for a developing limb may be caught between two of these bands, and as it grows be so constricted that the distal portion of the limb is entirely cut off from its blood-supply. Adhesions may also be formed between various portions of the body and the amniotic

Fig. 168.

Amniotic Bands (G. Braun): *a*, bridge of skin; *b*, liver; *c*, bony stump of the left lower extremity; *d*, left foot; *e*, right foot; *f*, vulva; *g*, anus; *h*, amniotic bands.

covering of the placenta, or the umbilical cord may be artificially shortened by the adhesions of coils one to another and to the fœtal skin.[1]

In the latter part of pregnancy the amnion can burst, the integrity of the ovum being preserved by the chorion.[2] The fœtus then by its active movements can roll the amnion up into cords which can become so entangled with the umbilical cord as to constrict it sufficiently to shut off the blood-supply to the fœtus.

Cysts of the Amnion.—Cases of cystic formations in the substance of the amnion have been reported by Ahlfeld, Winckler, and Budin.[3] They are small, and must not be mistaken for cysts derived from the allantois, chorion, or those the result of an effusion of blood upon the placenta under the amnion. They have no clinical significance. After the death of the fœtus the amnion undergoes certain changes, resulting in a loss of its glistening surface, usually observed, and in a considerable thickening. The histology of this change is, as Tarnier remarks, little known.

The Chorion.

When the ovule first drops into the uterine cavity and becomes imbedded in mucous membrane, the protoplasmic cell-wall sends out numerous prolongations, which have the purpose of fixing the egg in its position, and perhaps of drawing nourishment for the whole ovum from the blood-vessels of the uterine mucous membrane. This cell-wall, with its villus-like projections, constitutes the false chorion, which is soon to disappear and be replaced by the single layer of cells springing from the outer layer of the blastodermic membrane and surrounding the whole ovum. This membrane in its turn sends out branch-like processes, the villi of the chorion, which, at first non-vascular but hollow, soon receive into the interior of each branch of the villi loops of the blood-vessels that have been carried from the fœtus to the periphery of the egg by the allantois.

These vascular villi, then, absorb nutriment from the whole extent of the decidua reflexa until the third month, when they atrophy and finally disappear, except at that portion of the periphery of the ovum which is in direct contact with the decidua vera (decidua serotina), where the chorion villi develop still further and form what is known as the placenta.

The Fully-developed Chorion.—Restricting the term *chorion* to that portion of the original membrane which undergoes atrophy at the third

[1] Leopold: "Ein Fötus mit Verklebungen der Nabelschnur, etc.," *Arch. f. Gyn.*, Bd. xi. 383.

[2] Schroeder: *Lehrbuch*, 8th ed., p. 455.

[3] Tarnier et Budin: *loc. cit.*, p. 274.

month of pregnancy, it is found to consist of a thin transparent membrane made up of connective-tissue elements which are continuous with the substance of the umbilical cord, and very delicate, atrophied villi connecting it with the decidua reflexa. This portion of the chorion is called chorion læve to distinguish it from the chorion frondosum, that forms the placenta. The fibrous membrane constituting what is usually called chorion at term is derived from the endochorion, so called to distinguish it from the outer epithelial layer, the exochorion, which is to be found persisting in the epithelial covering of the placental villi.

Fig. 169.

Human Embryo at the Third Week, showing villi covering the entire chorion (Haeckel).

Diseases of the Chorion.—An abnormal condition of the chorion, but hardly to be classed as a disease, is the persistence of the chorion villi around the whole periphery of the ovum, thus completely enveloping the fœtus by the placenta.[1] If, however, instead of remaining normal in that they perform their physiological functions, the villi of the chorion undergo extensive degeneration, the consequences for the mother and fœtus, but especially the latter, are more serious. The degenerations, aside from the normal process of atrophy, that can affect the chorion villi are of two kinds—cystic and fibro-myxomatous.

Cystic Degeneration of the Chorion Villi.—This disease of the outermost of the fœtal envelopes is characterized by the hypertrophy of the chorion villi, by their conversion into cysts varying in size from that of a millet-seed to a grape or even to a hen's egg, connected with one another and with the base of the chorion by pedicles of greater or less breadth. It is further distinguished by the rapid growth of the ovum, and the consequent expansion of the uterus, usually at the third to the fourth month; by the early escape of blood from the uterine cavity into the vagina; and by the premature expulsion of the ovum, which is covered over a greater or less part of its surface with numbers of small, transparent cysts. Within the cavity of the ovum may or may not be found an embryo.

This affection of the chorion, from the peculiar and striking appearance that it gives to the ovum, has attracted much attention, and from the mystery that formerly surrounded its origin, and the difference of opinion that even yet exists as to its etiology and minute anatomy, cystic degeneration of the chorion villi, otherwise known as hydatidi-

[1] See *Am. Journ. Obstet*, 1886, p. 851.

form mole, vesicular mole, or dropsy of the chorion villi, has been the subject of much discussion. First definitely described by Schenk,[1] the most extraordinary theories have been advanced to account for its occurrence. Regnier de Graaf (1678) believed that each vesicle or little cyst was an unfecundated ovule. But much earlier than this the belief had prevailed, at least on one occasion, that each vesicle was a living embryo.[2] The opinion of Ruysch (1691) and Albinus (1754), that the existence of innumerable little cysts in the uterus and their final expulsion were dependent upon some disease or alteration of the ovule, became at last generally adopted. A more definite explanation, however, was not attempted until, in the early part of this century, it was claimed by Percy,[3] Cloquet,[4] and Boivin[5] that this vesicular disease depended upon the presence of echinococci. Velpeau[6] was the first to indicate that the cysts were nothing but the distended chorion villi—a fact that was soon acknowledged to be indisputable. Since this announcement of Velpeau's the cystic degeneration of the villi has been attributed to hypertrophy of the villi with œdema (Meckel, Gierse); to disease of the blood-vessels (Bartolin, Miller, Cruveilhier); to disease of the lymphatics (Bidlos, Sömmerring); to degeneration of the mucous substance within the villi, continuous with the substance of the cord (Virchow); and, finally, to a degeneration of the epithelial cells derived from the decidua, which replace the epithelial covering (exochorion) of the chorion (Ercolani). Virchow's[7] explanation is much the most satisfactory, and is the one generally accepted at the present time. According to this distinguished pathologist, the change that results in the cystic degeneration of the chorion villi takes place altogether in the endochorion, which forms the inner of the two layers that compose the chorion, and is continuous with the Wharton's jelly of the umbilical cord; this change consists in the over-production of true mucous tissue within the villi, into which the mucous tissue extends, at first alone, but afterward accompanied by blood-vessels. This process usually begins at a time when the villi are pretty equally developed over the whole ovum —that is, before the third month—and thus it is that when the vesicular chorion is expelled the disease is usually found equally distributed over the whole surface, showing no evidence of special development at any one point that might indicate where the placenta should have been situated. This general involvement of the whole chorion is the rule,

[1] See Tarnier et Budin, p. 299.

[2] See the interesting quotation by Priestley (*loc. cit.*, p. 36) from Ambroise Paré, "that the Countess Margaret . . . . brought forth at one birth 365 infants, whereof 182 were said to be males, as many females, and the odd one an hermaphrodite" (1276 A. D.).

[3] *Journal de Médecine*, t. xxii. p. 171, 1811.

[4] No. 1, *De la Faune des Méd.* (Priestley).

[5] *Nouvelles Recherches sur le Môle vésiculaire*, Broch., Paris, 1827.

[6] *De l'Art des Accouchements.*

[7] *Die Krankhaften Geschwülste*, i. S. 405.

but exceptionally it is the placenta alone that is affected, the disease having doubtless in such cases begun after the atrophy of the villi had taken place over the extra-placental portion of the chorion. Still more rarely will the disease be found in isolated spots upon the chorion læve.[1] But still more curious are those recorded cases in which one chorion of a twin conception was vesicular, while the other remained normal. It will be seen that according to this explanation the disease is a true myxoma of the chorion, and that the epithelial cells (exochorion) covering the villi do not necessarily take part in the morbid process. Priestley's[2] investigations, undertaken as long ago as 1858, gave results in accord with Virchow's theory: "The club-shaped extremities (of the villi) were observed to be distended with large nucleated cells," which were distended with fluid and were bounded by walls of extreme tenuity. As Priestley says, the discrepancy between his observation and Virchow's statement that the mucous tissue is contained in the intercellular substance is only apparent, for it is highly probable that the extreme distension of the cells by a gelatinous fluid is the first step in the formation of the mucous tissue, this being analogous to the production of Wharton's jelly in the cord.

Pathological Anatomy.—The appearance of a vesicular mole is striking and peculiar. The mass may be as large as a man's head, covered more or less completely with decidua, which upon incision, or in spots

FIG. 170.

Cystic Degeneration of the Chorion (Virchow).

where the decidual covering is absent, reveals innumerable small cysts, some as large as grapes or even as hen's eggs, connected one with the other or with the base of the chorion by pedicles of varying thickness. The liquid content of the cysts is usually clear and translucent. A microscopic examination of a section through a villus in the early stages of cystic degeneration will show the distended cells of which Priestley speaks, or else there may be seen the outer cellular and inner fibrous wall of a villus, while within the interior will be stellate connective-tissue cells, in the interstices between which may be found mucous tissue.

[1] Winogradow: *Virch. Arch.*, 1870, Bd. li. S. 146.

[2] *Loc. cit.*, p. 37.

The fluid contained in the cysts gives evidence on chemical examination of the presence of mucin and albumen in considerable quantities.

Fig. 171.

(A) Extremity of a Villus in Early Stage of Cystic Degeneration: *A* shows the first stage of enlargement in the cells of the villus trunk: *B*, a somewhat more advanced stage, showing hyaline cells escaping from the ruptured capsule of a young cyst (Priestley).
(B) Terminal Villus of Cystic Chorion: *A*, stellate connective tissue; *B*, *C*, inner and outer layers of wall; *D*, early stage of *B* (Braxton Hicks).

Within the centre of the vesicular mass is usually to be found a shrivelled or distorted fœtus surrounded by its amnion, which occasionally contains an abnormal quantity of fluid (hydramnion). Occasionally, however, no trace of an embryo is to be discovered, or at most there may be seen only the remnants of an umbilical cord. More rarely the fœtus, although dead, is apparently well developed for the date of pregnancy,[1] and if the degeneration of the chorion has not been too extensive, a living, healthy infant may be born along with a vesicular chorion.[2] It has been already noted that between amnion and chorion may be found a thin layer of jelly-like substance continuous with the Wharton's jelly of the umbilical cord. There is a case on record[3] in which this substance formed a layer 4 to 5 mm. thick originating from a mucous degeneration of the connective-tissue layer of the chorion, without involvement of the villi of either the chorion læve or frondosum, thus constituting a peculiar and, up to the present time, unique variety of myxoma of the chorion.

The relation of the cystic chorion to the two deciduæ is often peculiar and complicated. Occasionally the membranes retain their normal relative position of external deciduæ, median chorion, and internal amnion; but frequently the enlarged villi of the chorion perforate either one or both deciduæ over surfaces of varying extent. Thus, specimens have been described[4] in which the cystic mass was enclosed

[1] Priestley: *loc. cit.*, p. 42.
[2] Schroeder: *Lehrbuch d. Geb.*, 8th ed., p. 442; and Sym: *Edinb. Med. Journ.*, Aug., 1887, p. 102.
[3] *Wiener Med. Presse*, 1867, i.; and *Virch. Arch*, Bd. xxxix. H. 1.
[4] Priestley: *loc. cit.*, p. 40.

between the decidua vera and the reflexa, or in which the villi have perforated not only both deciduæ, but also the muscular wall of the uterus, and even its peritoneal covering.[1]

Fig. 172.

Cystic Chorion perforating the Uterine Walls (Spiegelberg).

Clinical History and Diagnosis.—There are three prominent symptoms associated with cystic degeneration of the chorion: (1) Rapid increase in the size of the uterus; (2) discharge of blood or bloody serum; and (3) the escape of vesicles. The last symptom is of rare occurrence, and the first two do not always manifest themselves in a typical manner, so that the clinical phenomena in a case of vesicular mole do not always permit of a definite diagnosis. Should there be an escape of blood at intervals during the early part of pregnancy, if the uterus rapidly enlarges toward the third month, and if careful palpation elicits no sign of the presence of a fœtus within the uterine cavity, the existence of a cystic chorion may be suspected. If, as rarely happens, characteristic cysts are expelled, there can be no doubt as to the nature of the case. Vesicular mole is most apt to occur in women who have already borne children or who have reached middle age. Hirtzmann[2] found that of 35 cases, 25 occurred in women over twenty-five years of age. As an exception to this rule, however, might be mentioned that authentic case described by Stricker[3] of precocious menstruation in a child who in her ninth year gave birth to a true vesicular mole. It is almost unnecessary to assert that, according to our knowledge of the formation of vesicular mole, it is necessarily a result of impregnation, and cannot occur in a virgin uterus—a fact that has proved of importance in deciding certain medico-legal questions. Cystic degeneration of the chorion will often occur in women who have previously given birth to healthy children, but it will not infrequently recur in the same individual. Depaul[4] mentions a woman who had this affection three times, and Mayer has[5] observed the disease in eleven successive pregnancies. The degenerated chorion usually determines the expulsion of the ovum at some period between the third and sixth months of gestation. If, however, the disease does not begin until after the villi of the chorion læve have atrophied, or if the degeneration is confined to a comparatively limited area, the pregnancy will usually

[1] Cory, quoted by Priestley, p. 41. Vollkmann, Waldeyer, Jarotzky, Krieger, Wilton, quoted by Schroeder, *op. cit.*, p. 444.

[2] *Thèse de Paris*, 1874.

[3] *Virch. Arch.*, Bd. lxxvii. S. 193.

[4] *Leçons de Clin. Obstet.*, 1872.

[5] Tarnier et Budin, p. 306.

go on to term. On the other hand, if the embryo is absorbed and the chorion becomes adherent to the uterine wall, the pregnancy may be abnormally prolonged to twelve or thirteen months (Schroeder). This adhesion of the cystic villi to the uterine wall has more serious results, however, than the mere prolongation of pregnancy. It is often due to the perforation of the uterine wall by the chorion villi, and consequently when the mass is expelled there may be fatal hemorrhage from the uterine sinuses (Volkmann, Waldeyer), or, as in Wilton's case,[1] the peritoneal covering may be torn and fatal hemorrhage ensue into the peritoneal cavity. Even if such serious accidents do not occur, the retention of a portion of the chorion may be followed by its decomposition within the uterine cavity, giving rise to general septicæmia. Or, as McClintock[2] pointed out, the fragments of cystic chorion retained in utero may go on proliferating, and may be expelled at a date remote from the original pregnancy. With these accidents, of not infrequent occurrence in the course of the disease, it is little surprising that the maternal mortality of cystic chorion is placed at more than 13 per cent.

Etiology and Frequency.—The occurrence of vesicular disease of the chorion cannot be attributed to any single cause, but, like hydramnion, the conditions which are responsible for its production are manifold, and may reside in either the mother or fœtus. The connection between disease of the endometrium (Virchow) or of the uterine walls (fibroid tumor—Schroeder) and vesicular mole is clearly established in a large proportion of the cases, especially in those in which there is a frequent recurrence of the disease; but this explanation will not suffice, as Priestley remarks, for the occurrence of the disease in the chorion of one fœtus while that of its twin remains healthy. In this case the disease is of fœtal origin, perhaps the result of the death of the fœtus. Indeed, it has been claimed (Graily Hewitt and others) that the death of the embryo necessarily precedes the cystic degeneration of the chorion. That this view is incorrect, however, is demonstrated by the birth of living children in certain cases of not too extensive degeneration of the chorion. It has been claimed also that vesicular mole is the result of an absence of the allantois (Hecker), or that possibly the allantois may, in certain cases, contain no blood-vessels (Schroeder), thus depriving the villi of their circulation.

Stenosis of the umbilical vein has been found associated with cystic chorion, and therefore it has been asserted that the cystic degeneration may have been due to dropsy of the chorion villi (Maslowski, Robin). As to the frequency of this affection there are no reliable statistics. Mme. Boivin saw the disease only twice in 20,375 pregnancies, while in the Charity Hospital[3] in Berlin it occurred four times in 2130 preg-

[1] *Lancet*, Feb., 1840. [2] *Clin. Mem.*, 1863.
[3] *Charité Annalen*, Bd. x.; *ib.*, xi.

nancies. The truth lies nearer to the last set of statistics than to the first, for, as Priestley says, every obstetrician of large practice has seen at least one case. Perhaps once in two or three thousand cases would be the true indication of the frequency of this disease.

Treatment.—The treatment of a pregnant woman affected with cystic degeneration of the chorion will be mainly directed toward the symptoms. Should there be excessive hemorrhage, it might be necessary to stop up the vagina with tampons until the os is sufficiently dilated to permit the expulsion of the cystic mass. If the diagnosis of cystic disease of the chorion should be made during pregnancy, and if abdominal or combined palpation gives no sign of the presence of a fœtus, the immediate induction of abortion would be advisable in order that the chorion might not have an opportunity to grow to inordinate size and push its way perhaps into the uterine wall, giving rise to hemorrhage or possibly to perforation of the uterus. After the expulsion of the diseased ovum, if there should be symptoms pointing to the retention and decomposition of fragments of chorion within the uterine cavity, the natural impulse would be to remove the offending substances; but it must be borne in mind that the attenuation of the uterine wall in circumscribed areas may be so great that the slightest interference, the introduction of a curette or the injection of an antiseptic solution, may cause its rupture with a fatal result.[1]

Fibro-myxomatous Degeneration of the Chorion.—If, instead of being thin and watery, the mucous tissue in the intercellular spaces of the degenerated villi should contain more fibrous elements, the resulting mass, instead of being cystic, would be solid. Virchow[2] first called attention to this condition in the placenta, and gave it the name of myxoma fibrosum placentæ. In this case, the first one described, in the midst of healthy cotyledons one was discovered affected by this fibro-mucous degeneration. A similar structure may be found in the peripheral layers of the umbilical cord.

To complete the study of diseases of the chorion it only remains to mention briefly a chronic inflammation of the membrane.[3] In that case, already referred to, in which the amnion was ruptured during pregnancy, the irritating effect of the liquor amnii upon the chorion produced a thickened and hyperplastic condition of that membrane.

The Placenta.

The placenta, as a separate organ, may be said to date from the third month of pregnancy, for it is at that time that the chorion villi atrophy

[1] For a case resulting fatally after the injection of perchloride of iron see Priestley, *loc. cit.*, p. 41.

[2] *Op. cit.*, S. 414

[3] Lebedeff, quoted by Tarnier, *op. cit*, p. 313.

over the whole periphery of the ovum, except at the point where it comes in direct relation with the true mucous membrane of the uterus, that portion of the decidua vera which goes under the name of decidua serotina. Here the villi take on an extraordinary growth, sending out branches in every direction, into each of which a loop of blood-vessels is projected. Separating the villi from one another, and dipping down to the base of the chorion between the parent stems of the villous projections, are at first capillary loops, and afterward large blood-spaces, containing maternal blood. So far, almost all authorities are agreed, but as to the relation of the terminal villi to the uterine mucous membranes, as to the action of the chorional and decidual epithelium, and in regard to the changes that convert the uterine capillaries at first surrounding the villi into the large blood-sinuses that are later found in the placenta, many conflicting theories have been advanced. In regard to the relation between the placental villi and the uterine mucous membrane it has been variously stated that the former enter the mouths of the uterine glands (Bischoff); that they sink into crypts in the uterine mucous membrane which are new formations especially adapted for their reception (Turner); that the villi do not sink into glands or crypts, but are intimately invested with a layer of decidual epithelium (Ercolani); and that this epithelial covering acts as a glandular structure, secreting from the maternal blood a peculiar substance, the so-called "uterine milk," which acts as nutriment for the fœtal blood (Ercolani, Hoffmann).[1] It is now well enough established, however, that the placental villi imbed themselves in the soft interglandular substance of the decidua serotina, and that the uterine epithelium rises up in embankments around them, the decidual and the chorional epithelium remaining, however, distinct from one another. The uterine mucous membrane at this early period is richly supplied with capillary blood-vessels, from which loops are thrown around the villi in such fashion as to form a complex but very distinct network throughout the placental mass (Priestley). Later, these capillaries disappear, and in their place are seen the large sinuses, to which blood is conveyed from the maternal circulation by little curling arteries that wind their way up through the decidual epithelium and empty directly into the placental sinuses. These arteries are provided with only a delicate endothelial wall. Whether, now, the placental villi projecting into these sinuses are directly bathed in the maternal blood, or whether they are invested with an endothelial covering derived from the maternal blood-vessels

[1] For the sake of clearness, but at the risk of being pronounced dogmatic, the writer has refrained from giving an analysis of the controversial papers that have appeared on this subject, but will endeavor to succinctly state the theory as to the development of the placenta—that is, to the best of his belief, as nearly correct as possible with the present extent of our knowledge of the subject.

in addition to their proper epithelial covering, is a matter still in doubt, although most careful observers have failed to detect this double investment of the villi. However this may be, it is unnecessary to say that the fœtal blood cannot possibly mix with the maternal blood, but that the former derives oxygen and nutriment through the medium of the epithelial cells (exochorion) that surround each villus, and which clothe the parent trunks and the base of the chorion. This epithelial covering of the villi undergoes some remarkable changes during the development of the placenta. It becomes irregularly thickened, and in the thickened parts undergoes hyaline degeneration, producing the canalized fibrin first accurately described by Langhans.[1]

The Fully-developed Placenta.—The placenta after its expulsion from the uterus is seen to be a somewhat oval-shaped mass, measuring about 7 inches in its longest diameter, being about $\frac{2}{3}$–1 inch in thickness at the point of insertion of the cord, and weighing about 16 ounces. Upon that surface of the placenta into which the cord enters is seen a smooth, shining membrane continuous with the sheath of the cord, the amnion. This surface, the fœtal side of the placenta, contrasts strongly with the opposite, the maternal surface. This is of a dark-red hue, divided by deep sulci into lobules of irregular outline and extent, the cotyledons. Over the maternal surface of the placenta is stretched a delicate, grayish, transparent membrane, which is made up of the cells that compose the upper layer of the decidua serotina. This constitutes the maternal portion of the placenta. It will be seen, therefore, that in separating from the uterine wall the line of separation is not found to divide the fœtal from the maternal structures, but to be in the mucous membrane of the uterus, in the lower portion of the cellular layer of the decidua—a point to be more fully referred to later under the title of "The Deciduæ." Around the periphery of the placenta may be seen a large vein, the circular vein of the placenta, which returns a part of the maternal blood from the organ, the rest returning to the maternal circulation by means of the continuity between the placental lacunæ and the uterine sinuses. The situation of the placenta within the uterus may with equal frequency be found either upon the posterior or the anterior wall—occasionally, however, upon one of the lateral walls, more frequently the right (Schroeder).

A perpendicular section through the middle of a placenta which is still attached to the uterine wall will reveal the most intimate connection between the two. So close, indeed, is the connection between placenta and uterus that, as has been said, the line of separation when the placenta is cast off is found in uterine tissue. This close adhesion between the fœtal and the maternal portions of the placenta is explained by Langhans, who calls attention to the manner in which the delicate

[1] See Minot: *Boston Med. and Surg. Journ.*, June 2, 1887.

terminal villi, and even branches of a millimeter in thickness, are imbedded in the upper portion of the decidua, and held in place by their extremities bulging out into club-shaped masses, so that the exer-

Fig. 173.

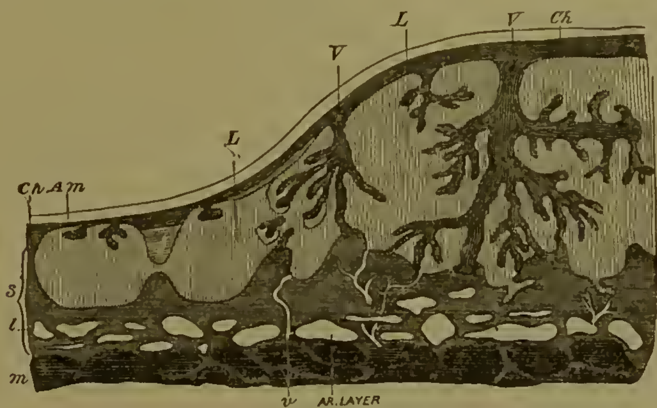


Diagram of Uterus and Placenta in the Fifth Month: *Ch*, chorion; *Am*, amnion; *V*, villi; *L*, lacunæ; *s*, serotina; *ar*, areolar; *v*, small arteries (Leopold).

cise of considerable force will not extract them from the uterine mucous membrane, but will, instead, always lacerate the maternal structures.

The functions of the placenta are manifold. Not only does it act as a lung, or rather gill, in oxygenating the fœtal blood, but it may be said to take the place of the alimentary tract in absorbing nutritive material from the maternal circulation.[1] It is probable, moreover, that it plays the part of an excretory organ, getting rid not only of the surplus carbonic oxide gas in the fœtal blood, but also of the other waste products of a tissue-activity that in the rapidly-growing fœtus must be so great. Indeed, a very plausible explanation of the albuminuria and kidney diseases that are so frequent in pregnant women has been based upon the supposition that during pregnancy the maternal kidneys are called upon to get rid of the waste products of two organisms. As Bernard has shown that in the earlier months of pregnancy the placenta has a glycogenic function, we must regard it at this time also as a vicarious liver. The epithelial cells of the chorion villi must, however, take something more than a passive part in the passage of substances to and fro between the fœtal and the maternal blood. This is proven by a fact to which attention will later be called; that is, the comparative ease with which certain pathogenic micro-organisms—as, for instance, those of variola—pass from mother to fœtus, while the bacilli of tuberculosis, a disease often present in pregnant women, are almost never found in the fœtus; and also that certain drugs (iodide

[1] It has recently been reasserted that the only function of the placenta is that of a lung or gill, and that the fœtus is nourished altogether by swallowing or absorbing through the skin amniotic fluid (v. Ott, *Arch. f. Gyn.*, Bd. xxvii.).

of potassium, benzoic acid, bichloride of mercury) enter the fœtal from the maternal blood, while it is asserted that others, as woorari, will not pass to the fœtus from the mother. Again, while nutritive material must pass from mother to fœtus, the escape of the same material from the fœtal into the maternal blood would prove destructive to the fœtus. It would seem, therefore, as if a limited power of selection must be attributed to the chorional epithelium.

ANOMALIES OF THE PLACENTA.—The placenta may present deviations from the normal in regard to size, position, shape, weight, or number, or its structure may present anomalies the result of diseases or accidents; and as a further result of the same cause there may be anomalies of function.

Anomalies of Position, Size, and Weight.—The position of the placenta is normally near the fundus uteri. A lower insertion will, all the more surely as it approaches the internal os, give rise to the condition known as placenta prævia, to be more fully described in its appropriate place. The size of the placenta may vary considerably. As Schroeder says, the thickness of the organ will be in inverse ratio to its extent, and the younger the ovum the greater is the relative size of the placenta. The placenta, instead of being confined to that portion of the ovum which is in contact with the decidua serotina, has been known in rare cases to extend around its whole periphery. This condition is known as *placenta membranacea*, and is to be explained, of course, by the equal development of all the chorional villi. On the other hand, the placenta may be abnormally thick and enlarged in all directions, owing to an irritation from a chronically inflamed endometrium, which results in a hyperplastic condition of both the maternal and fœtal portions of the organ. Such a placenta may give rise to hydramnion by the excessive extent of its secreting surface. An abnormally small placenta may be associated with an ill-developed child or may depend upon an interstitial overgrowth with subsequent retraction, or upon atrophy of the decidua.

Anomalies of Shape and Number.—The placenta, usually round or oval, may have a horseshoe or crescentic shape, especially if it is inserted near the internal os, which in these cases is surrounded by the two arms of the crescent. A single child may have two (*placenta duplex*), three (*placenta tripartita*), or more (*placenta multiloba*) placentæ. Or a single placenta may be reinforced by one or more small accessory placental developments (*placentæ succenturiatæ*), which are in in direct communication with the blood-sinuses of the decidua vera. Should the villi of these accessory growths not communicate with the maternal blood, the growths are called *placentæ spuriæ*.

DISEASES OF THE PLACENTA.—The pathology of the placenta is already complicated, the morbid conditions that may be discovered being most diverse in their etiology, mode of development, and minute anatomy, so that it is no longer possible to admit, as was once asserted, that there is only one morbid process to be studied in the placenta—a fibro-fatty degeneration.

Œdema of the Placenta.—A serous infiltration of the whole placenta is often observed in those cases in which a dead fœtus has been retained some time within the uterus, and has become macerated.[1] The same condition is often found associated with general anasarca of the fœtus, with some obstruction of the umbilical vein or of the venous system of the fœtus, or with a greatly hypertrophied placenta which absorbs more fluid than the fœtal economy can dispose of (Werth). The minute anatomy of the placenta can remain normal in this disease, and the placenta may continue to perform its physiological functions.

Degeneration of the Placental Villi.—The morbid processes that result in such grave alteration in the structure of the placental villi as to abrogate their physiological activity are of radically different natures, and may best be studied separately under their respective titles of cellular hypertrophy, fibrous and fatty degeneration, phthisical placenta, and calcareous and myxomatous degenerations. Placental hemorrhages, placental syphilis, and solid tumors of the placenta have, as a result, the destruction of all or a part of the placental villi as factors in the nourishment and aëration of the fœtal blood, but these conditions will be considered separately.

Cellular Hypertrophy.—Ercolani[2] has described, under the name of "cellular hyperplasia and hypertrophy of the parenchyma of the placental villi," a disease that is characterized by the extensive multiplication of the cellular elements in the villi to such an extent as often to obliterate the blood-vessels and give the placenta a hard, dense appearance and feel that has been called by other writers sclerosis of the placenta, and has been attributed to the over-production of fibrous tissue. Cellular hypertrophy may also be seen in syphilitic disease of the villi.

Fibrous and Fatty Degeneration of the Placenta.—A fibrous and fatty change in the placental villi is extremely common, and isolated examples of it may be found in almost every placenta, especially toward the periphery of the organ. It is necessary to consider the two together, for they are always found in common, except when the degeneration of the placenta follows the death of the fœtus. In this case there is a simple fatty change without other pathological process (Barnes). It has been claimed by some observers, as Barnes[3] and Kilian,[4] that fatty degeneration of the placenta may be the primary pathological process, and may originate independently of other degenerative changes; and it

[1] Tarnier et Budin: *op. cit.*, p. 329.

[2] *Delle Malattie della Placenta*, Bologna, 1871.

[3] *Med.-Chir. Trans.*, 1851.

[4] *Neue Zeitschr. f. Geburts.*, 1850.

has also been asserted that this degeneration is only an exaggeration of the condition that normally obtains in the placenta toward the end of pregnancy; but most modern investigators will agree with Robin and Ercolani that the fatty change is subsequent to other degenerative processes, most frequently an abnormal development of fibrous tissue—a condition that might be termed interstitial placentitis. This development of fibrous tissue must be carefully distinguished, however, from the fibrous change that occurs in blood-clots due to effusion from the maternal capillary loops in early pregnancy, or to thrombosis in the placental lacunæ later on. In accordance, then, with the belief that a fibrous change usually precedes the fatty degeneration, it will be well to first glance at what has been called interstitial placentitis, but which has been also variously named sclerosis of the placenta, or by earlier writers scirrhous, tuberculous, or cartilaginous degeneration. The fact that an inflammation of the placenta can occur has been denied, for there are no capillaries in the maternal portion, nor are there nerves to govern the dilatation of the capillaries in the fœtal tufts; and therefore the present accepted theory in regard to inflammation cannot be applied to the placenta. But as the process that ends in the overproduction of connective tissue is precisely analogous to what occurs in cirrhosis of the liver or in fibroid phthisis in the lungs, it would seem that the theory, and not the facts, is at fault. The fibrous change, consisting in the displacement of the normal structures by fibrous tissue, by the atrophy of the former either from the pressure exerted by the hypertrophied fibrous elements or by their subsequent contraction, may originate either in the decidua serotina, the placental villi, or the intervillous spaces.

When the disease affects the decidua serotina, it is associated with chronic inflammation of the remainder of the endometrium, and it would be better perhaps, with Braun, Schroeder, and Spiegelberg, to regard this not as a disease of the placenta, but as an endometritis. As the disease progresses, however, the placenta becomes secondarily involved, either by the encroachment of the hypertrophied decidua upon the intervillous spaces, and the consequent compression of the villi, or by the agglutination of the different layers of the membrane one to another, which may result in the firm adherence of the placenta to the uterine wall. Hegar and

Fig. 174.

The Maternal Portion of the Placenta, showing elongated decidual cells, the first step in interstitial placentitis.

Maier, and many others since them, have described this disease as interstitial endometritis.[1]

The same microscopic appearance may be seen in an hypertrophied decidua throughout its extent, and is not confined to the placental site. It is, however, possible to find an endometrium in an advanced stage of hyperplastic inflammation, while the upper layer of the decidua serotina remains unchanged, even although the placental site itself is immensely thickened by new-formed connective tissue and enlarged blood-sinuses. In such a case, an example of which I have seen, the placenta remains unaffected.

The fibrous degeneration may have its seat in the placental villi alone. The process that transforms a healthy villus containing blood-vessels into a bundle of connective tissue can well be studied in the extra-placental villi of the chorion, which normally undergo a fibrous degeneration as they begin to atrophy at the third month of pregnancy. The mucous tissue in the interior of the villi becomes converted into fibrous tissue, the blood-vessels are obliterated, and the villi shrink, atrophy, and become more or less infiltrated with fat. This same process may be seen in isolated villi of almost every placenta. If the process becomes more extended, the functions of the placenta are naturally abrogated. According to Ercolani, the cellular covering of the villus also takes an active part in its fibrous transformation. According to Neumann,[2] the interchange between fœtal and maternal blood may be prevented by the great hypertrophy of the placental villi, and their consequent encroachment upon the maternal blood-spaces.

The development of connective tissue may take place in the intervillous spaces—a condition to be carefully distinguished from the fibrous mass that results from the effusion of blood or the occurrence of thrombosis in the same situation. The development of the fibrous tissue has been ascribed by Simpson, Rokitansky, Scanzoni, Priestley, and others to an inflammation followed by an exudate which organizes into connective tissue. Priestley has recently described, under the name of placental phthisis, a pathological condition of the placenta brought about in this way: The first stage of the disease, says this author, consists of an exudation or deposit thrown out among the villi, probably due to some modification of a low inflammatory process, the result of which is a sort of "hepatization" of the part affected. The mass thus formed either remained dense and firm throughout, or else in the centre might be found a crumbled and disintegrated substance resembling the result of cheesy degeneration of tuberculous masses in the lung. As a result of this disintegration there may be found evidences of hemorrhages in blood-clots at different stages of organization.

The result of fibrous degeneration of the placenta, wherever the dis-

[1] *Virch. Arch.*, 1871.

[2] See Priestley: *loc. cit.*, p. 54.

case originates, is to prevent the performance of its most important vital functions, and if the pathological condition involves a large area of the organ, it must prove destructive to the fœtus. The deprivation of their blood-supply determines the fatty degeneration, or in some cases amyloid degeneration,[1] of the placental villi. This fatty infiltration is the more marked, as a rule, the older the original lesion. Thus, Bustamente's[2] description of a "sclerotic" placenta as presenting a reddish, flecky, lobulated, or smooth mass resembling the thymus would be applicable to a fibrous placenta in which fatty degeneration had not advanced very far. In the latter case the organ would present a paler, yellowish hue. The diagnosis of fibro-fatty degeneration of the placenta is impossible during pregnancy. Such a condition may be inferred if there is a history of the previous repeated occurrence of the disease. It was in such cases especially that Simpson recommended the administration of chlorate of potassium.

Myxomatous Degeneration.—The myxomatous degeneration that has already been studied in the chorion villi may be confined to the placenta, while the extra-placental chorion remains healthy. Myxoma fibrosum placentæ has already been described. This affection has been observed by Virchow,[3] Storch (2 cases),[4] Hildebrandt,[5] and Sinclair;[6] and, as Priestley says, the case of sarcoma of the placenta described by Hyrtl should be placed under this head. In this category also, according to Schroeder, should be placed the tumors of the placenta described by Clarke[7] and Löbl.[8]

Calcareous Degeneration.—Depositions of small quantities of lime in the placenta are not at all uncommon. They are usually to be found in that portion of the maternal placenta lying nearest the villi, or they may originate in the villi themselves. Chambord[9] has found as many as five hundred concretions in one placenta. It has been said that extensive calcification of the placenta is more apt to occur after the death of the fœtus, but Tarnier asserts that there is no relation of cause and effect between the two, and that the occurrence of large calcareous deposits in the placenta with stillborn children is a mere coincidence, as it is also in those cases in which calcareous degeneration has been associated with syphilis.[10]

Placental Syphilis.—Whether there is a form of diseased placenta that is peculiar to syphilis, and is found associated with no other con-

[1] Green: *Am. Journ. Obstet.*, 1880, p. 279.
[2] *Thèse de Paris*, 1868.
[3] *Loc. cit.*, p. 414.
[4] *Virch. Arch.*, 1878, und Breus' *Wiener Med. Wochenschr.*, 1881, No. 40.
[5] *Monat. f. Geb.*, Bd. xxxi. S. 346.
[6] *Journ. Obstet. Soc.*, Boston, 1871.
[7] *Phil. Transactions*, London, 1798, ii. p. 361.
[8] *Zeitschr. d. Ges. d. Wiener Aerzte*, 1844, S. 231.
[9] *Lyon Médical*, 1873, p. 431.
[10] See also Fränkel, *Arch. f. Gyn.*, Bd. ii. S. 373; Winckler, *Arch. f. Gyn.*, Bd. iv. S. 260; Langhans, *Arch. f. Gyn.*, Bd. iii. S. 150.

dition, is a question which according to Tarnier, Depaul,[1] and Priestley[2] remains as yet unsettled. That the placenta, however, is often, if not uniformly, the seat of morbid processes when the mother or the fœtus is syphilitic is now no longer doubted; but the point at present in dispute is in regard to the specific and characteristic nature of the lesions to be found in the placenta in such a case. The investigation of this subject is of quite recent date. From the end of the last century, when Astruc first called attention to the fact that syphilis of either parent was apt to result in the birth of stillborn and macerated children, until the appearance of D'Outrepont's paper[3] in 1830, the opinion prevailed that the cause of the repeated fœtal deaths must be sought for in syphilitic disease of the viscera. It was this last-named author who first called attention to the influence of diseases of the placenta upon the nourishment and the life of the fœtus. Shortly afterward followed Simpson's well-known work,[4] and ever since all pathological conditions of the placenta have been investigated with increasing care, and the changes associated with syphilis have received especial attention. Virchow was the first to divide the study of placental syphilis into the investigation of the lesions in the maternal and in the fœtal portion of the organ, and to consider apart the changes in the decidua serotina (endometritis placentaris gummosa) and those in the extra-placental decidua (endometritis decidualis). No considerable advance was then made in the knowledge of placental syphilis, although the subject was investigated by many observers, until Slavjansky and Kleinwächter[5] called attention to the development of fibrous nodes "of a syphilitic nature" in the fœtal portion of the placenta, and the degeneration of the epithelium in the placenta materna. In 1873 appeared Fränkel's well-known paper, in which this author claimed to be the first to demonstrate that the "deforming granular hyperplasia and hypertrophy of the placental villi," already described by Ercolani—without, however, reference to its connection with syphilis—was the most frequent form of placental syphilis.

According to Fränkel, this infiltration of the villi with granulation-cells, and their consequent increase in size and distorted shapes, are characteristic of syphilis, and might serve to make certain the diagnosis of the disease. As to the seat and extent of the lesion, they vary with the manner and time of the fœtal infection. If the ovule is infected by the impregnating spermatic particle, the placenta, if diseased at all, will constantly present the granulation-cell infiltration of

[1] Tarnier et Budin: *op. cit.*, p. 40. [2] *Loc. cit.*, p. 63.

[3] "Ueber die Krankheiten u. Abnorm. der Placenta," *Gem. Deutsche Zeitschr. f. Geburtsh*, Bd. v. 518.

[4] *Edin. Monthly Journ. of Med. Sci.*, Feb., 1845; *Obstet. Works*, vol. ii. p. 445.

[5] See Fränkel: "Ueber Placentar Syphilis," *Arch. f. Gyn.*, Bd. v. S. 6.

the villi and the degeneration of their epithelial covering. If the mother is infected during the fruitful coitus, there may be endometritis placentaris, characterized by the enormous overgrowth of the decidual cells or the overgrowth of connective tissue, as well as syphilitic disease of the villi. If the mother is syphilitic before conception, the

FIG. 175.

Section of Villi, showing small cell-infiltration and the deformed shapes of villi: *A A*, luxuriant cell-development in the interior; *V V*, lumen of blood-vessels with hypertrophied walls; *B*, villus in which only a trace of blood-vessels can be seen at *S S*; *C*, villus without trace of vascular canal; *D*, epithelial covering (Fränkel).

disease of the placenta takes the form of endometritis placentaris gummosa. If the mother is infected during the later months of pregnancy, the placenta usually remains unaffected. Fränkel bases these conclusions upon the examination of more than one hundred specimens, and his views have been confirmed by Hennig[1] and MacDonald.[2] Specimens of syphilitic placentæ in my possession show very well the condition of the villi described by Fränkel, but exhibit even more clearly the condition of the placenta materna known as endometritis placentaris gummosa, in which the decidual cells are enormously increased and overgrown, encroaching deeply upon the intervillous spaces and undergoing in places cheesy degeneration. In one case, in which the mother was infected at about the fifth month of pregnancy, the placenta materna at birth was greatly thickened, and showed under the microscope an extraordinary development of connective tissue. The fœtal placenta and the child itself were perfectly healthy.

In their macroscopic appearances syphilitic placentæ can differ considerably. If the child has been dead some time, the placenta may be almost white in appearance and soft and greasy in feel.[3] If the child

[1] *Arch. f. Gyn.*, Bd. vi. S. 141. [2] *Br. Med. Journ.*, Aug., 1875, p. 234.

[3] Charpentier: "Syph. héréditaire," 1870, *Presse Méd. Belge*, No. 8.

is expelled alive at term, the placenta is often unusually large and of a pinkish color, due to the thickened decidua, which prevents the true color of the organ from appearing. Very often there are organized clots, showing a previous hemorrhage into the placenta or the occurrence of thrombosis in the lacunæ; or else there may be found nodes[1] of a greater or less extent, lamellated in structure, and undergoing degenerative changes in the central portions. Often, too, there is found extensive calcareous degeneration of the organ, but Tarnier says that this is a mere coincidence.

The consequence of syphilitic disease of the placenta is usually disastrous to the fœtus and often dangerous to the mother. The cellular infiltration of the villi results in the obliteration of the blood-vessels within them, and consequently makes the performance of their functions impossible. The same effect may be produced by the hyperplasia of the decidua serotina and the consequent encroachment of the decidual tissue upon the intervillous blood-spaces, or the destruction of the villi may be brought about by the formation of the nodular masses that have been noticed. All these processes, if, as is the rule, they invade the whole area of the placenta, must of necessity be fatal to the fœtus. The endometritis placentaris that is often a prominent feature of placental syphilis may prove dangerous to the mother by so matting the different layers of the placenta together as to occasion a close adherence of that organ to the uterine wall, thus subjecting the woman to the perils of hemorrhage, septicæmia, or inversion of the uterus that are incidental to adherent placentæ.

The accurate diagnosis of placental syphilis is impossible during pregnancy. This condition may be inferred with considerable certainty, however, should a history of syphilitic infection be obtained from either parent.

The treatment will be referred to later under the head of Fœtal Syphilis.

Placental Hemorrhages.—The term placental hemorrhage is used to indicate those circumscribed collections of blood that have undergone more or less marked change so frequently found in the placenta. The blood may be found in the shape of a fresh clot, sometimes occupying a very large area, especially in those cases in which abortion occurs as a result of the hemorrhage, or the extravasated blood may be encapsulated, surrounded by a fibrous wall of varying thickness, within which may be found a reddish or a brownish fluid, or the cyst may contain nothing but clear serum, while the coloring matter of the blood is deposited upon the cyst-wall or upon the surrounding villi.[2] The

[1] Ziller: *Studien über Erkrankungen der Placenta, etc.*, Tübingen, 1885.

[2] Ercolani has described a case of "placental melanosis" in which there was no trace of blood-extravasation, but the villi were infiltrated with pigment-granules (*Arch. de Toc.*, 1876, p. 193).

encysted hæmatocele, on the other hand, may contain large numbers of white blood-corpuscles undergoing fatty degeneration, giving rise to a liquid resembling pus. It is such cases, according to Tarnier, that have been described as abscesses of the placenta by Brachet, Cruveilhier, O'Farrell, and Simpson.

Again, the fibrin may predominate, especially in those cases of thrombosis in the placental sinuses described by Bustamente[1] and Slavjansky,[2] when, if the clot is slowly formed, the resulting mass will consist of laminated fibrin, such as one sees in aneurisms undergoing obliteration. In other cases the serum is rapidly absorbed, and there is left a mass of red globules containing white corpuscles, either aggregated together or scattered through the mass. Finally, the clot may organize through the process described by Weber and confirmed by Virchow, and thus form a distinct neoplasm in the placenta. The placental villi surrounding the extravasated blood usually undergo a fibro-fatty change.

The causes of placental hemorrhage are manifold. The predisposing causes may be stated to be those that lead to apoplexies elsewhere in the maternal system, as congestions (Simpson) or albuminuria (Winter, Fehling); the slow-moving blood-current in the placental sinuses and the excess of fibrin in the blood of pregnant women, predisposing to thrombosis (Bustamente); and diseased conditions of the placental villi (Charpentier and others). The determining cause may be a sudden, powerful action of the heart, producing at the same time perhaps apoplexy of the placenta and the brain; or syncope, favoring the formation of a thrombus; or external violence. In the early months of pregnancy it is more frequently a true apoplexy that gives rise to the hemorrhage, from rupture of the delicate capillary loops of maternal origin that surround the villi. Later, it is more frequently thrombosis in the sinuses, or the laceration of the delicate blood-vessels that perforate the upper layer of the decidua serotina to enter the placental sinuses.[3]

The consequences of placental hemorrhage to the fœtus depend upon the amount of blood extravasated. Should the quantity be large, either the number of villi strangulated by the clot is so great that the fœtus is at once asphyxiated, or else the escaping blood is able, especially in the earlier months, to strip the placenta off from the uterine

[1] *Loc. cit.* [2] *Arch. f. Gyn.*, 1873, Bd. v. S. 360.

[3] My friend Dr. Robt. H. Hamill of Philadelphia has recently shown me a specimen exhibiting what is, as far as my knowledge goes, a unique variety of placental hemorrhage. Immediately beneath the amnion there was a large clot occupying more than half the area of the placenta, and evidently containing all the blood of the fœtal body. The fœtus, corresponding in development to the fourth month, had bled to death into its own placenta from the rupture of a large branch of the umbilical vein due to some undiscoverable cause.

wall, with the same result. The effect of placental hemorrhage upon the mother is usually unnoticeable, except in case the fœtus is killed, when the whole ovum will be prematurely expelled. In some instances, however, the blood will force itself between the placenta and uterus, and, burrowing its way downward through the layers of the deciduæ, will make its appearance externally as a hemorrhage from the uterus. Or else the blood, unable to escape, will collect at the placental site, or possibly over a larger area, sometimes in such quantities as to form distinctly an additional tumor of the uterus appreciable through the abdominal walls, and also to give rise to all the symptoms associated with serious loss of blood, these constituting those dangerous cases of concealed hemorrhage so often fatal in their results, unless the uterus be rapidly emptied of its contents that the organ may properly contract.

Placentitis.—An interstitial placentitis has already been described. Older authors paid particular attention to inflammations of the placenta, and Simpson described three stages of the disease—the first characterized by congestion, the second by plastic exudation, the third by suppuration. Numerous instances have been recorded in which "pus" was found in the placenta, but the majority of the cases reported will not stand modern investigation. There are, however, authentic instances of such an occurrence.[1]

Cysts of the Placenta.—Cystic formations may be found not very infrequently in the placenta. In the majority of cases they are the result of certain changes in extravasated blood. They are sometimes, however, to be ascribed to a circumscribed, unusually fluid myxoma.[2] Jacquet[3] has described small cysts springing from the blood-vessel walls.

Tumors of the Placenta.—The tumors that have been described by Clarke, Löbl, Marduel, and Hyrtl as fibromata and sarcoma of the placenta may be classed as myxomata fibrosa. Organized blood-clots have also been described as tumors of the placenta. Hecker[4] speaks of a fleshy substance expelled from the uterus post-partum, although the placenta had come away entire as possibly a placental tumor. This may, however, have been nothing but a uterine polypus or a piece of hypertrophied and angiomatous decidua serotina,[5] or a so-called polypoid hæmatoma of the placenta, placental polyp, or placental adenoma.

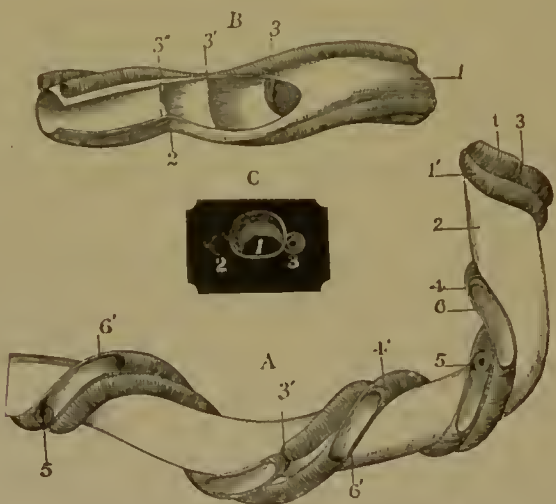
The Umbilical Cord.

The early development of the umbilical cord—or, in other words, the formation of the allantois—has been studied upon the lower animals, as

[1] See Schroeder: *Lehrbuch*, ed. of 1884, p. 450.
[2] *Arch. f. Gyn.*, Bd. xi. S. 397.
[3] *Gaz. méd. de Paris*, Oct. 14, 1871.
[4] *Klinik der Geburtsh.*, 1864.
[5] See paper by the writer in *Am. Journ. Obstet.*, Dec., 1887.

in all the human embryos observed the connection between the embryo and the chorion was already established. Indeed, according to His, the human embryo is from the first in connection with the periphery of the ovum. Very early, then, in embryonal life there may be observed a sac-like projection from the posterior end of the intestinal tract, which, at first solid, but later containing a canal, grows outward and backward, owing to the presence of the large umbilical vesicle anteriorly, until it comes in contact with the periphery of the ovum. Within this sausage-shaped (*ἀλλᾶς*, a sausage) projection are blood-vessels, which are carried with its growth to the periphery of the ovum, where they enter the villi of the chorion in the manner already described. Becoming reduced to two arteries and a vein within the allantois itself, they constitute the vessels of the umbilical cord, which are destined to carry the blood of the fœtus to the placenta for aëration and nourishment, the two arteries conveying dark venous blood, the vein returning bright oxygenated blood, resembling in this respect the pulmonary arteries and vein. Surrounding the blood-vessels of the cord is a peculiar gelatinous substance, furnishing the vessels the most perfect protection possible under the circumstances—the so-called gelatin of Wharton—derived

FIG. 176.



A, umbilical arteries forming spirals (1, 1′) around the vein; constrictions indicating the presence of folds (3, 3′); circular folds (5, 5′); lateral openings showing the arterial walls. B, vein opened upon the side, showing a constriction (2) corresponding to an interior valve (3″); semilunar valves (3, 3′, 3″). C, section of vein and arteries, showing valve of vein (1), a semilunar arterial valve (2), and a circular arterial valve (3) (Tarnier et Chantreuil).

from the outer layers of the amnion and the allantois, both in their turn being derived from the median layer of the blastodermic membrane. As the amniotic cavity becomes distended, the amnion is pushed out on all sides till it meets in front of the embryo and surrounds the cord like the finger of a glove, at the same time enclosing the already atrophied umbilical vesical, the ductus omphalicus, and the pedicle of the allantois. That portion of the allantois that remains within the abdominal cavity forms the bladder and urachus. The umbilical cord at term measures about 20 inches in length and about $\frac{1}{3}$–$\frac{1}{2}$ an inch or more in diameter, this latter being irregular, from the fact that the arteries are coiled around the vein, usually from right to left, giving a twisted appearance to the cord, and also because the gelatin of Wharton is deposited irregularly, being in some places quite thick, and forming thus the so-called false knots of the cord.

Both the arteries and the veins of the cord have walls of almost the same thickness, and both are provided with semilunar valves. The calibre of the vein is greater than that of the arteries. According to Leopold,[1] it measures normally 2–4 mm. in diameter, but at a point about 8–10 cm. from the placental insertion there occurs a physiological narrowing.

ANOMALIES OF THE CORD.—The cord may be abnormally long, measuring rarely as much as 70 inches,[2] or may be naturally or artificially too short. The cord is artificially shortened in those adhesive inflammations of the amnion which may result in the gluing together of the coils or their attachment to the fœtal skin or amnion.

Exaggerated Torsion.—The cord may be so twisted upon its longitudinal axis that the vessels are nearly or quite obliterated, and the cord itself, especially near the umbilicus, is reduced to a very small diameter. Formerly the torsion was regarded as a cause of fœtal death, but Martin, Ruge, Schauta, and most modern observers regard the exaggerated torsion of the umbilical cord as a post-mortem occurrence, resulting from the great movability within the uterine cavity of a fœtus that has died during the fifth to the seventh month of pregnancy. The number of twists in the cord may be surprisingly great. In Schauta's[3] case it reached 380. Torsion occurs more frequently in male than in female children. Œdema and cystic degeneration may often be found in connection with exaggerated torsion.

Stenosis of the Umbilical Vessels.—The umbilical vein may be narrowed by the development in the intima of new connective tissue[4] to such an extent as to seriously impede the flow of blood from the placenta—a condition resulting in œdema of the latter organ, hydramnion, or an immense dilatation (to 15 mm.) of the undiseased portion of the vein, ending occasionally in its rupture (Leopold) and the extravasation of blood into the substance of the cord. This disease of the vein is usually attributed to syphilis. A periphlebitis may also

[1] *Arch. f. Gyn.*, Bd. viii. S. 221.

[2] Chantreuil: *Disposition du Cordon*, Paris, 1875.

[3] Leopold: *Arch. f. Gyn.*, Bd. xvii. S. 20; see also Winckel: *Berichte u. Studien.*

[4] *Neue Zeitschr. f. Geb.*, Bd. iv. S. 62; and Leopold, *loc. cit.*

occur, and may diminish somewhat, but not seriously, the calibre of the vein. The umbilical arteries are occasionally obstructed by atheroma and thrombosis.

The section of an umbilical cord taken from a syphilitic infant will sometimes show an enormous development of connective tissue throughout the entire wall of the arteries, so that it is impossible to distinguish the different coats; the lumen of the vessels is often obliterated, not only by the thickened walls, but by the infiltration of the whole substance of the cord with granulation-cells. Pinard[1] has seen the vessels of the cord obstructed by an over-development of the valves that are found in both arteries and veins.

True Knots of the Umbilical Cord.—Rarely, the fœtus slips through a loop of the cord, and, the two ends of the loop being then put upon the stretch, a true knot is tied. This process may be repeated either during pregnancy or while the child is descending in labor, and thus a double knot is tied. In the case of twins in a common amniotic cavity the most complicated knotting of the two cords may occur. The effect of these knots in the cord upon the circulation of the fœtus is usually not serious. Carl Braun[2] says that he has never seen the slightest disadvantage to the fœtus from this cause; but the knots can be drawn so tight as to completely shut off the placental blood-supply, especially in the case of twins in a single amniotic cavity, where one cord may be drawn in a tight knot about the other, obliterating the latter's blood-vessels. The gelatin of the cord is often displaced at the seat of the knot, so that when the latter is untied its situation is marked by deep depressions.

Coiling of the Cord around the Fœtus.—Loops of the cord may be wound about different portions of the fœtal body. The neck may be encircled once or twice, more rarely from four to nine times (Braun), or loops may be thrown around the limbs. The encircled part may be so compressed that it is strangulated and the distal portion is destroyed, but it is doubtful whether a constricting cord can ever determine the amputation of a part, for when it sinks through the soft tissues to the bones it there experiences a pressure greater than it itself can exert, and is therefore in its turn destroyed (Braun). Thus the neck has been severed to the spinal column, and limbs have been cut through to the bone, but there the process will usually stop.

Marginal Insertion of the Cord.—The cord is usually inserted somewhere near the centre of the placenta. As the insertion approaches the edge of that organ the condition receives the name of marginal insertion, or sometimes battledoor placenta. If the cord should first enter the membranes at some little distance from the placenta, to and from which the vessels, unprotected and more or less separated from one

[1] *Dict. encyclopéd. des Sc. méd.*, art. "Fœtus." [2] *Lehrbuch der Ges. Gynäk.*, p. 552.

another, pursue their course between the amnion and chorion, a condition known as insertio velamentosa exists. The explanation of such an occurrence is obvious: The allantois is conveyed at first indifferently to any portion of the periphery of the ovum, but as the placenta begins to be differentiated the embryo, by a movement of rotation, enables the umbilical vessels to pursue a straight course toward their insertion in the placenta. Should the rotation of the fœtus be in any way interfered with, or should the newly-formed umbilical cord contract adhesions with the amnion or chorion that would prevent the vessels following or complying with the rotation of the embryo, they would naturally enter the membranes opposite the abdominal face of the embryo, or at that point where adhesions arrested their movements. The blood-vessels thus exposed are liable to laceration during labor, usually with a fatal result to the fœtus unless delivery is quickly effected.

Umbilical Hernia.—Occasionally children are born with a greater or less portion of the abdominal contents protruding into the umbilical cord, and covered by nothing but the distended and attenuated amnion. In such cases, if the opening in the abdominal walls is not too extensive, prompt surgical interference may effect a cure.

Cysts of the Cord.—Cystic formations in the cord are due either to an abnormally fluid condition of the mucous tissue or else to a collection of serum in the pedicle of the allantois, which in horses, swine, and cows is found persisting as a vesicle up to the time of birth.

Calcareous Degeneration.—This condition of the cord is occasionally found to a greater or less degree, usually associated with syphilis. The lime may be deposited in the walls of blood-vessels or in the substance of the cord.

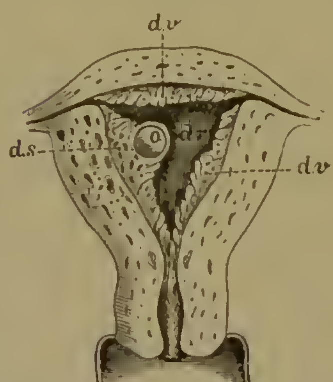
The Deciduæ.

The explanation which John Hunter gave of the plates published by his brother William[1] was for a long time accepted as the true history of the development of the uterine membrane which envelops the fœtus at term. The Hunterian theory was that the uterus threw out upon its inner surface an inflammatory exudate, forming a closed sac whose walls stretched across the openings of the tubes and the os internum cervicis. As now the impregnated ovule entered the uterus from one of the tubes, it pushed the sac-wall in front of it, but left behind it a bare surface, which was soon, however, covered by an exudate similar to the one at first thrown out. That portion of the original membrane which remained attached to the uterine wall Hunter called the membrana vera; that portion pushed out in front of the ovule, membrana reflexa; and that membrane *last* formed behind the ovule, the membrana

[1] *Anatomæ ut. hum. grav. tab. illustr.*, Birm., 1774, table 34.

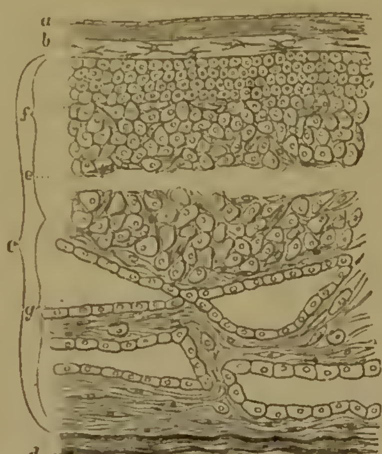
serotina. These names have survived till the present day, although modern investigation has robbed them of their original significance. Costi[1] was the first to expose the fallacy of the Hunterian doctrine, and since his time the investigations of Robin, Friedländer, Kundrat, Leopold, Engelmann, and others have enabled us to follow the changes that occur in the uterine mucous membrane from the entrance of the impregnated ovule into the uterine cavity until the fœtus, with its enveloping membranes, is expelled at term. By the time the fertilized ovum arrives within the uterine cavity the lining mucous membrane of the uterus has become very much thickened,[2] owing to a great increase in the interglandular connective tissue, which consists of enormously enlarged young connective-tissue cells, either closely pressed together or separated from one another by the cellular amorphous substance characteristic of newly-forming connective tissue. As a consequence of this thickening the mucous membrane is thrown into folds, and it is in a depression between two of these folds of membrane that the ovule falls and lodges as it first enters the uterine cavity. The ovule, being thus imbedded in the uterine mucous membrane, is gradually enclosed by

Fig. 177.



Imbedding of the Ovum in the Decidua: *d. v*, decidua vera; *d. r*, decidua reflexa; *d. s*, decidua serotina; *o*, ovule (Schroeder).

Fig. 178.



Section through the Decidua (Friedländer): *a*, amnion; *b*, chorion; *c*, decidua; *d*, uterine muscle; *e*, line of separation in the cellular layer; *f*, cellular layer; *g*, glandular layer.

the arching over of the folds of the membrane, or, as Leopold[3] claims, by their simple approximation, owing to the increasing thickness of the mucous membrane. That portion of the uterine mucous membrane upon which the ovule rests, formerly called membrana decidua serotina,

[1] "Origine de la Caduque," *Acad. des Sciences*, Paris, 4 et 25 Juillet, 1842.
[2] Tenfold, according to Engelmann (*Am. Journ. Obstet.*, May, 1875).
[3] *Arch. f. Gyn.*, Bd. xi. S. 455.

is now more properly termed by the French the placental decidua, for it is upon this spot that the placenta will be developed; that portion of the membrane which arches over the ovule, called by Hunter the decidua reflexa, is better named the ovular or epichorial decidua; and that portion of the mucous membrane that remains as at first, attached to the uterine wall, the decidua vera of Hunter, is now more appropriately spoken of as the uterine decidua. The changes that occur in this last division of the uterine mucous membrane as pregnancy advances are, up to a certain point, only a continuation of the change already noted. The large cells already referred to, the decidual cells of Friedländer, multiply with great rapidity, and constitute a thick layer, the upper portion of the uterine decidua. The glands which at first send their ducts up through the cellular layer of decidua seem at last to be confined entirely to the deeper portions of the membrane, constituting, finally, what is known as the glandular layer. In its early stage of development the uterine decidua is richly supplied with blood; the capillary loops spring up luxuriously into the interglandular spaces; while deeper down, between the glandular layer and the uterine muscle, may be found numerous and extensive blood-sinuses. As, however, the ovular decidua comes in contact with the uterine layer, the blood-vessels are subjected to pressure and the stage of atrophy begins in the uterine decidua. The blood-vessels disappear, a fatty degeneration may be seen to begin in the cellular layer, no trace of epithelium remains in the superficial layer of the membrane, although epithelial cells persist in the glandular layer; and finally, as labor begins, the uterine decidua separates into two parts, the line of division running through the cellular layer, as is indicated in the drawing, while a part of the cell-layer and the whole of the glandular layer remain behind in the uterus to furnish the nucleus of a new mucous membrane which soon after labor takes the place of that which has been partly cast off. The history of the ovular decidua is one of atrophy almost from the beginning. As the growing ovum pushes out this portion of the uterine mucous membrane upon that pole of the sphere directly opposite the placental decidua, the epithelium of the membrane begins to disappear, and the blood-vessels are soon obliterated, so that at the end of the third month, when the ovular comes in contact with the uterine decidua, the former consists of not much more than a single layer of flattened and elongated cells. The development of the placental decidua has been described with the development of the placenta.

Diseases of the Deciduæ.—The decidual mucous membrane of the pregnant uterus may be the seat of any of the diseases that attack the endometrium of the non-gravid womb. In the former state, however, diseased conditions often manifest themselves in exaggerated forms, owing to the enormous hypertrophy that the mucous membrane of a pregnant uterus frequently exhibits. In consequence of its relation to the fœtus, too, a disease of the decidual endometrium can produce more serious effects than a similar affection of the uterus in a non-gravid state.

Diffuse Hyperplastic Inflammation of the Decidual Endometrium.—The atrophy of the deciduæ which normally occurs during the latter part of pregnancy may not take place, but in its stead the mucous membrane may go on to an increase of that hyperplasia which is a constant phenomenon in the earlier stages of its development. The cause of this over-development will usually be found in a pre-existing morbid condition of the endometrium, which predisposes it to respond with inordinate vigor to the stimulus which an impregnated ovule always furnishes the uterine mucous membrane to rapid growth and development. The pre-existing lesion is a chronic endometritis, either of ordinary type or of syphilitic or gonorrhœal origin. It may be possible, however, that the death of the embryo or some disease of the ovum may prove irritating enough to incite the mucous membrane of the uterus, previously healthy, to overgrowth. As the constituent parts of the mucous membrane are more or less affected, so will the manifestations of the disease vary.

Diffuse Hyperplasia of the Decidual Endometrium.—This condition of the mucous membrane consists in a simple progression of the hyperplasia that has been noticed as occurring normally in the early months of pregnancy, but which in these cases was, from the beginning, exaggerated. The steady increase in all the elements of the decidua with greater or less rapidity results in the production of a membrane of varying thickness and density, but always far in excess of the size of the normal deciduæ at term. Should the disease advance with great rapidity, an abortion will usually result, either on account of hemorrhages into the mucous membrane, separating it from the uterine wall, or owing to the death of the embryo, from which all nourishment has been diverted to supply the greater needs of the rapidly-growing decidua. In such cases the embryo may be absorbed, and the deciduæ afterward cast off as an empty sac with greatly thickened walls, forming one variety of the so-called fleshy moles.[1] Or the embryo may be destroyed in consequence of the hemorrhages into the hypertrophied decidua, the blood bursting its way through all the membranes and occupying the cavity of the ovum, as well as surrounding it exteriorly, so that only with a microscope can one detect the true nature of the mass expelled.[2]

On the other hand, if the development of the decidua goes on slowly and evenly, the fœtus may not be expelled before it becomes viable, or

[1] Schroeder: *Lehrbuch.*

[2] Priestley: *loc. cit.*, p. 28, who quotes Gendrin, Hegar, and Westmacott.

even until the normal end of pregnancy.[1] The structure of the hypertrophied decidua is usually only an exaggeration of what may be seen in the decidua of early pregnancy. There is a great multiplication of the decidual cells, some of which are elongated and seem to be transforming themselves into connective tissue; the blood-sinuses are much enlarged in the deeper portions of the membrane; and there is usually an abundance of connective tissue, or else, as Priestley describes it, an abundant exudation, which, at first simply amorphous or granular, soon becomes fatty, owing to the abundance of the exudate or its low vitality, which prevents the formation of the connective tissue that would otherwise develop from this plastic exudate. Madame Kaschewarowa[2] has described new-formed muscular fibres in an hypertrophied decidua, and occasionally either the cellular or the fibrous element has been found to greatly predominate.

The cause of hyperplastic decidual endometritis has been already referred to. The determining cause of the hemorrhages or "apoplexies of the ovum" so often destructive of the embryo and provocative of abortion in this affection, may be anything that would produce congestion of the pelvic viscera—physical exertion, full habit, or the recurrence of the menstrual period.

The effect of this disease upon the embryo or fœtus is, as may be imagined, usually disastrous; but upon the mother also the result of chronic endometritis decidualis may be injurious. The hemorrhages into the decidua may grow excessive in amount, but more frequently the maternal health is endangered by the retention of portions of decidua, varying in size, owing to adhesions between the diseased membrane and the uterine wall,[3] after the rest of the ovum is cast off. Especially is the placental decidua apt to surpass in its hyperplastic growth the remainder of the decidual membrane and to be retained in utero to give rise to hemorrhages, or by its decomposition to septicæmia. This is doubtless the condition described by Braun as placental polyp, and by Virchow, Winckel,[4] and others as polypoid hæmatomata of the uterus,[5] or by Klotz as placental adenoma.[6]

Polypoid Endometritis.—Instead of being evenly and generally thickened, the decidua may display at certain points a less-pronounced hypertrophy, or, on the other hand, upon the uterine surface may be

[1] I have seen a living fœtus, delivered at the sixth month, from a woman who three days afterward expelled a piece of decidua quite 1 cm. thick and measuring 5-6 cm. in diameter.

[2] *Virch. Arch.*, 1868, Bd. xliv. p. 103.

[3] This seems to be particularly true of syphilitic endometritis. See Kaltenbach, *Zeitschr. f. Geburt.*, Bd. ii. p. 225.

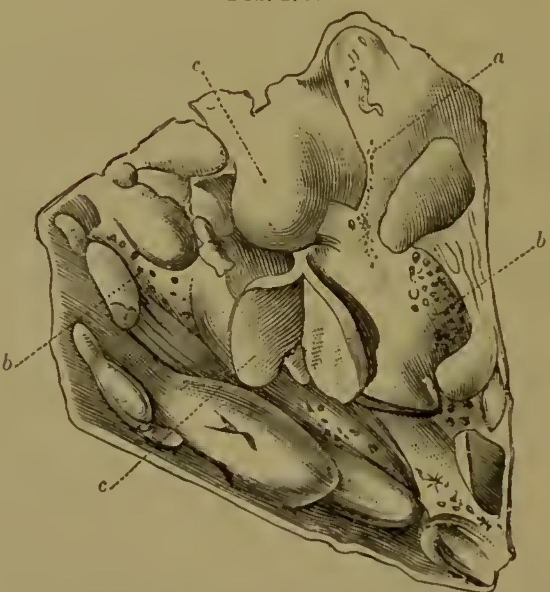
[4] *Path. u. Ther. des Wochenbettes.* p. 168.

[5] See paper by the writer in *Am. Journ. Obs.*, Nov., 1887.

[6] *Arch. f. Gyn.*, Bd. xxviii. H. 1.

seen projections or excrescences where the hyperplastic process seems to have been exaggerated over a limited area. Such cases have been described by Hofe[1] and Schroeder.[2] It is, however, to the most ad-

FIG. 179.



Polypoid Endometritis (Virchow): *a*, fine apertures of the glands; *b*, larger apertures of the glands; *c*, protuberances or polypi.

vanced type of this polypoid condition of the uterine mucous membrane that Virchow[3] first gave the name of endometritis decidua polyposa or tuberosa.

In these cases the internal surface of the decidua presents a most peculiar appearance. Villus-like projections stand out from the degenerated mucous membrane to the height of half an inch or more, smooth of surface and very vascular. In the intervals between the projections may be seen the openings of the uterine glands, which are not to be found on the polypoid elevations. The whole membrane is greatly thickened, which, as a microscopic examination shows, is due to the great hypertrophy of the connective-tissue elements and to a great increase in the decidual cells, which contain nuclei of enormous size. The connective tissue forms fibrous bands constricting the openings of the uterine glands, as well as the blood-vessels in the diseased membrane; and yet the whole decidua is exceedingly vascular. In Virchow's case there was a syphilitic history, and therefore this author ascribes the disease to syphilis; in other instances no cause whatever could be discovered; but often this disease, as well as other affections of the decidual endometrium, depends upon a pre-existing chronic

[1] D. I., Marburg, 1869: *Ueber Hyperplasie der Decidua.* [2] *Op. cit.*, p. 402.
[3] *Die Krankh. Geschw.*, Bd. ii. S. 478.

endometritis. It is a disease of young ova, and frequently the chorion villi implanted in the diseased mucous membrane are in a condition of myxomatous degeneration.[1] In all the cases hitherto described the ovum has been expelled at the end of the second to the fourth month of pregnancy (Schroeder).

Catarrhal Endometritis.—A chronic inflammation of the decidual endometrium will occasionally affect chiefly the glandular elements of the membrane, with the result of a hypersecretion of a thin, watery mucus, which, collecting between the chorion and deciduæ, may be suddenly expelled, after a rupture of the ovular decidua, in the later months of pregnancy. This gives rise to sudden gushes of fluid from the vagina, which may occasionally reach a pint in quantity. Afterward the fluid may dribble away for a considerable length of time without affecting seriously the course of pregnancy, or else, collecting again in considerable quantities, it may excite the uterus to muscular action. This affection occurs more frequently in multiparæ than in primiparæ, and seems to depend in some cases upon a watery condition of the woman's blood. This condition is known as hydrorrhœa gravidarum. The escape of watery fluid occurs at intervals in gushes or constantly over a long period during pregnancy, and must be distinguished from a rupture of the membranes and the escape of amniotic fluid, which occurs but once and is soon followed by the expulsion of the uterine contents. Tarnier and Budin,[2] however, insist upon the occurrence of an amniotic hydrorrhœa characterized by the escape of amniotic fluid over a more or less extended period, and due to a rupture or perforation of the amnion at a point far removed from the eventual seat of rupture over the os internum. In support of this view these authors point to a specimen in the museum of the Maternité showing an aperture in the amnion remote from the point of rupture, round and regular as if cut out with a punch; and, moreover, they describe two cases that came under the clinical observation, the one of Ingleby, the other of Tarnier himself, in which apertures were found in the amnion far from the seat of rupture, and in which there had been an escape of fluid respectively three months and six days before the labor began. Erlich[3] has recently reported a case of interest in this connection in which the amnion was perforated by the sharp end of an ill-developed tibia that projected through the fœtal skin. This accident resulted in abortion.

Cystic Endometritis.—If there should be a hypersecretion of the uterine glands, and the escape of the fluid contained in the glandular spaces should be hindered, a condition results only found in very young ova, known as cystic endometritis. It is not improbable that

[1] Müller, *Bau der Molen.* 1867.
[2] *Op. cit.*, p. 324.
[3] *Virch. Arch.*, Bd. c. p. 107.

this condition might be found pretty constantly in the earlier stages of the chronic hyperplastic decidual endometritis already described, the glands being destroyed and obliterated as the disease advances. A section of mucous membrane affected with cystic disease presents a somewhat cavernous appearance, numerous small cysts being scattered throughout its thickness. Their connection with the uterine glands can be demonstrated by the relation between the cysts and the ducts of the glands.[1] About the cysts the decidua is hypertrophied, presenting the over-development of connective tissue, increase of decidual cells, and embryonal tissue that has already been referred to.[2]

As to the prognosis of all these chronic affections of the decidual endometrium, it is, as may be inferred, decidedly unfavorable for the fœtus and by no means entirely favorable for the mother. The danger to the fœtus from hemorrhages, which bring about separation of the membranes, or which, bursting through all the fœtal envelopes, overwhelm the embryo with blood, has been mentioned, as well as the diversion of nutriment from the embryo to the overgrown decidua, and the excitation of muscular action upon the part of the uterus which ends in the expulsion of the ovum. But the possible loss of blood during pregnancy, and the retention of fragments of decidua owing to adhesive inflammation, after the ovum is expelled, cannot be regarded with indifference as to their effect upon the mother.

The treatment of this condition during pregnancy is impossible. Its prevention may be attempted, however, by treating the chronic endometritis of ordinary or specific origin which almost invariably is the cause of the disease in the decidual membrane.

Acute Inflammations of the Deciduæ.—It is in the course of cholera and other infectious, but especially the exanthematous, diseases, or in consequence of unsuccessful attempts to bring on abortion, or perhaps as a result of external injuries, that acute inflammation of the decidual membrane may be developed.

Hemorrhagic Decidual Endometritis.—This is the name given to that condition of the mucous membrane that Slavjansky[3] found in two cases associated with cholera. In these instances the decidua was thickened, of a dark purplish hue, and presented throughout its substance numerous extravasations of blood. It is not improbable that the same condition might be found in other acute febrile infectious diseases.

Exanthematous Decidual Endometritis.—Klotz,[4] in a very interesting study of the effect of measles upon pregnancy, presents the authentic history of 11 cases of this disease in pregnant women, in 9 of which

[1] Leopold: *Gesellsch. f. Geburtsh.*, Leipzic, Feb., 1878.

[2] See Breus: "Ueber cystöse Degeneration der Decidua vera," *Arch. f. Gyn.*, Bd. xix. S. 483.

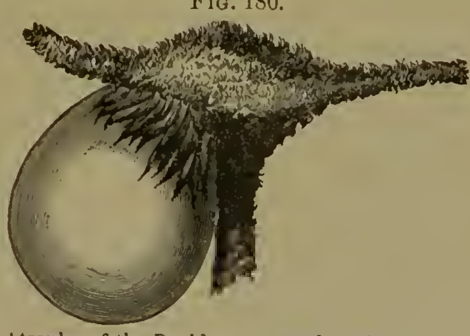
[3] *Arch. f. Gyn.*, Bd. iv. S. 285.

[4] *Ibid.*, Bd. xxix. S. 448.

there was a premature expulsion of the fœtus, the time at which the expulsive efforts began seeming to bear a certain relation to the outbreak of the eruption upon the skin. In these cases, according to Klotz, the uterine action is excited by the occurrence of an exanthema upon the uterine mucous membrane, highly irritating in its action, just as the photophobia, the coryza, the bronchitis, and the vesical tenesmus of measles indicate an irritated condition of the mucous membranes of the eyes, nose, lungs, and bladder. It is quite probable that the same condition of the uterine mucous membrane might account for the abortions or premature labors that often occur when pregnant women are attacked by any of the eruptive fevers.

Purulent Decidual Endometritis.—Donat[1] has described a case of this nature. A woman expelled at term a placenta about the periphery of which could be seen masses of decidua infiltrated with pus. The amnion and chorion were both thickened and opaque, and between them was a collection of purulent fluid, which, according to Donat, must have broken its way from the decidua through the chorion, and have collected between that membrane and the amnion. A most careful macroscopic and microscopic examination left no doubt whatever as to the nature of this case. It was suspected that the suppuration of the decidua was the result of unsuccessful attempts on the part of the woman to bring on a miscarriage. It has occurred to the writer, however, that pus might perhaps be pressed from a collection in a distended tube into a pregnant uterus, breaking its way through the ovular decidua in the latter part of pregnancy, or penetrating between the layers of the deciduæ in the earlier months, thus giving rise to a condition similar to that described by Donat. It is well known that quite a gush of pus may escape from a pyosalpinx into an unimpregnated womb, and there seems to be no reason to doubt the possibility of such an occurrence during pregnancy.

Fig. 180.



Atrophy of the Decidua, external surface of the vera (Duncan).

Atrophy of the Deciduæ.—The deciduæ, instead of undergoing inflammatory and hyperplastic changes, may, on the contrary, atrophy, although such an occurrence is doubtless rare. This change in the decidual membranes has been described by Hegar[2] and Matthews Duncan,[3] and among recent writers by Spiegelberg[4] and Priest-

[1] *Arch. f. Gyn.*, Bd. xxiv.
[2] *Monatsch. f. Geburtsh. u. Fr.*, Bd. xxi.; *Supplem.*, pp. 11, 19, 1863.
[3] *Researches in Obstetrics*, p. 295, 1868.
[4] *Lehrbuch*, p. 328.

ley.[1] The uterine, ovular, or placental deciduæ may singly or conjointly be the seat of atrophy, resulting either in the ovum being attached by a mere pedicle of slender proportions to the uterine wall, or else, in the case of atrophy of the ovular decidua, the embryo lacks the outermost of its protective membranes, and consequently the ovum may rupture and its contents be discharged from the uterus. As a result of the stretching of the pedicle in cases of placental atrophy, the ovum may be pushed downward by the uterine contractions until it rests in great part within the cervical canal. This condition constitutes the cervical pregnancy of Rokitansky.

The Diseases of the Fœtus.

The protection afforded the fœtus by its position within the uterine cavity, where it is apparently shielded from all unfavorable external influences, would seem, on first thought, designed to give the product of conception a complete immunity from many of the morbid processes which might afterward threaten its independent existence. But, bearing in mind the rapid and active growth which in a few months transforms a simple cell into the most complex being of all animal creation, and the ease with which the normal progress of this development might be disturbed; considering the fact that the most important vital functions are performed without the body of the fœtus in an organ subject to accidents and diseases; reflecting, moreover, that the fœtus is essentially a parasite, whose well-being is entirely dependent upon the health of its host,—it is little surprising to learn that the fœtal mortality exceeds that of any other period of life. It has been estimated that for every five labors (Parvin) there has occurred one abortion, and if to this number be added the stillbirths in which the death of the fœtus was not due to an accident in labor, the proportion of fœtal deaths to living births becomes very large. And in addition to the diseases having a fatal termination there are others affecting the fœtus in utero, running their course wholly or in part during intra-uterine life and ending in recovery; so that the category of fœtal diseases, whether affecting the fœtal organism alone or its appendages, or consisting in some disturbance of the maternal health which reacts injuriously or fatally upon the fœtus, is already an extensive one, and must in time become richer in the number and variety of diseases observed as the habit of recording interesting cases becomes more general, and the facility with which such records are collected from all quarters of the globe increases from year to year.

The study of the many morbid processes which can exert an unfavorable influence upon the growth and development, upon the health or the

[1] *Op. cit.*

life, of the fœtus is of course surrounded with many difficulties; but it is not a study of purely theoretical interest, barren of practical results, for many of the affections which will come under consideration are susceptible of modification in their course or of a complete cure by a rational system of therapeusis. Those tendencies to disease, those constitutional vices, which, impressed upon the ovule at the moment of conception or acquired during intra-uterine life, only manifest themselves at some period more or less remote from birth, will not be considered in this place.[1] Nor will the diseases of the fœtal appendages, for they have been already described, so that the present section will treat of the diseases of the fœtal organism itself, of structural weaknesses dependent upon defects in the paternal elements entering into the composition of the embryo, along with certain conditions of the maternal organism which are incompatible with the healthy development or with the continued existence of the product of conception.

Fœtal Syphilis.

First in importance, because foremost in frequency, protean in its manifestations, and most destructive in its action upon the development, the health, and the life of the fœtus (of all the diseases of intra-uterine life), fœtal syphilis deserves careful consideration. According to Ruge,[2] 83 per cent. of premature and still births have their cause in syphilis of one or both of the parents—a percentage which, large as it is, must be further increased to include the number of syphilitic children born alive, if one would estimate the relation that syphilis bears to the other diseases of intra-uterine life. The almost infinite variety in the manifestation of fœtal syphilis is perhaps more remarkable than the polymorphism of the disease acquired in adult life, and the fatality attending the affection in the fœtus may be learned from the statistics of abortion and premature labor in syphilitic women, or in cases where the disease is transmitted to the product of conception from the paternal parent alone. Of 657 pregnancies in syphilitic women collected by Charpentier,[3] 35 per cent. ended in abortion, and of the children that went to term a large number were stillborn.

The Syphilitic Infection of the Fœtus.—In the strict sense of the word the syphilitic infection of the fœtus is comparatively a rare occurrence. In the majority of cases, if the woman be syphilitic the ovule is already diseased before its impregnation; or the spermatic particle from a syphilitic man carries to the ovary of a healthy woman the poison of this disease; or, again, if both man and woman are diseased,

[1] See section on "Diseases of the Newborn Infant," Vol. II.

[2] See Lomer: *Zeitschr. f. Geburts.*, Bd. x. p. 189.

[3] *Traité pratique des Accouchements.*

all the more surely will the product of the union of an ovule and a spermatic particle, both syphilitic, display in a marked degree the signs of hereditary syphilis. Modern investigation tends to show, moreover, the possibility of infecting the healthy fœtus at any time during intra-uterine life should the mother acquire syphilis during pregnancy. This statement of the manner in which syphilis is inherited or transmitted may seem a trifle dogmatic in view of the fact that there is by no means a universal agreement upon the subject; but the evidence in favor of the views expressed is to the writer's mind quite convincing. No one, of course, now denies the fact that a woman infected before or at the time of impregnation will probably produce syphilitic offspring, but as to the possibility of the infection of the embryo by the father while the mother remains healthy there is still some difference of opinion. Collerier, Notta, Follin, Charnier, Mireur, Langlebert, Corry, Wolf,[1] and quite recently Schadeck,[2] have said that they do not believe that the infection of the fœtus is possible unless the mother is syphilitic; but of modern authorities, Tarnier,[3] Schroeder,[4] Charpentier,[5] Priestley,[6] and many others assert their positive belief that syphilis can be transmitted from a syphilitic father direct to the embryo without the previous infection of the mother. As the fœtus grows, however, and the syphilitic poison develops with its growth, the mother often becomes infected in her turn directly from the fœtus through the utero-placental circulation.[7] The longer the time since the acquisition of the disease by either parent, the less likelihood will there be of the production of syphilis in the embryo; but the limit of safety has not yet been discovered. According to Fournier,[8] four years is the maximum of time that syphilis can remain latent, but Lomer[9] tells of the production of a syphilitic infant ten years after the first infection of the father, and Kassowitz[10] records a latent syphilis of twelve years' duration.

In regard to the infection of the fœtus by syphilis acquired at some time during pregnancy by the mother, it has been said that "the syphilitic poison will not traverse the septa intervening between the fœtal and the maternal vascular systems;" but, on the other hand, Vajda[11] and Hutchinson[12] describe cases in which pregnant women were infected near term and gave birth to syphilitic children. Neumann[13] also has

[1] Tarnier et Budin, t. ii. p. 36.
[2] *St. Petersburg med. Wochenschr.*, 16, 17, 1886.
[3] *Loc. cit.*, p. 36.
[4] *Lehrbuch der Geburtshülfe*, 8th ed., 1884, p. 375.
[5] *Traité pratique des Accouchements.*
[6] "Pathol. of Intra-uterine Death." *Rep. of Br. Med. Journ.*, 1887.
[7] See Tarnier et Budin, *op. cit.;* Priestley, *loc. cit.;* J. Hutchinson, *Br. Med. Journ.*, Feb., 1886, p. 239; Harvey, *Fœtus in Utero*, 1886; G. S. West, *Am. Journ. Obstet.*, 1885, p. 182.
[8] *Syphilis et Mariage.*
[9] *Zeitschr. f. Geb.*, Bd. x. p. 94.
[10] *Stricker's Jahrb.*, 1875, p. 476.
[11] *Centralb. f. Gyn.*, 1880, p. 360.
[12] *Br. Med. Journ.*, 1886, i. 239.
[13] *Wien. med. Presse*, 29, 30, 1885.

published his observations of 20 women who were infected with syphilis during pregnancy; 5 of this number gave birth to syphilitic children, and of these 5, 2 were infected at the fourth and 1 each at the third, seventh, and eighth months. But most strongly confirmative of this opinion of the transmissibility of syphilis from the mother to the fœtus during pregnancy are the observations of M. Hirigoyen[1] in the Maternity Hospital at Bordeaux: Of 12 cases in which the mother contracted syphilis during the first four months of pregnancy, all the children were stillborn; in those cases in which infection occurred from the fourth to the sixth month about half the children were stillborn; and in 7 cases of infection during the last three months of pregnancy there were 4 stillbirths.[2] Admitting, then, that a pregnant woman, having acquired syphilis, can transmit it to the fœtus in utero, it seems reasonable to admit also that the converse of this proposition must likewise be true: that a fœtus, infected by the syphilitic spermatic particle of its father, can convey the poison to its mother, in both cases the *materies morbi* passing through the delicate membrane that separates the fœtal from the maternal circulation. And this belief is strengthened by the fact that the investigations of Lustgarten,[3] Doutrelepont,[4] Chotzen,[5] and others tend to show that the specific poison of syphilis is "a particulate and living virus,"[6] for we know that certain pathogenic micro-organisms at least have the power of traversing the utero-placental septum.[7]

Manifestations of Fœtal Syphilis.—Syphilis having been acquired by the embryo at the moment of conception from pre-existing syphilis of the ovule or of the spermatic particle, or of both, or having been transmitted to the fœtus from the mother at any time during pregnancy, its manifestations during fœtal life can assume the greatest variety in the tissues attacked and the lesions produced. A description, however, of all the pathological processes traceable to syphilis which have been seen in aborted ova or in children prematurely born could be of interest only to the pathologist. It will be sufficient merely to mention the bullous eruptions of the skin, the condylomata and inflammations of the mucous membranes, the inflammations of the serous membranes, the gummatous and miliary deposits, and the morbid growth of connective tissues in the brain, lungs, pancreas, kidneys, liver, and spleen, the muscular system, and the coats of the intestines and walls of the blood-

[1] Abstract in *N. Y. Med. Record*, April 12, 1887.

[2] The author has seen a woman, impregnated by a healthy man, but infected with syphilis in the third month of pregnancy, give birth to a child with a pemphigoid eruption upon it and a liver twice the normal size.

[3] *Die Syphilis Bacillen*, Vienna, 1885.

[4] *Jahrschr. f. Dermatol. u. Syph.*, xiv. H. i. p. 101.

[5] *Ibid.*, p. 109.

[6] J. Hutchinson: *Br. Med. Journ.*, 1886, i. p. 279.

[7] Koubassoff: *Comp. rend. Acad. d. Sc.*, Paris, 1885, 101.

vessels, and a characteristic osteitis and osteo-chondritis. Some of these manifestations of fœtal syphilis, however, deserve more than a passing mention, for from their constant presence and characteristic features a diagnosis of the disease can almost invariably be made—a matter of considerable importance, as will be seen when we come to consider the habitual death of the fœtus in utero and its preventive treatment.[1]

The influence of syphilis upon intra-uterine life is, as a rule, most deleterious if not fatal. If the fœtus is not destroyed before it has become viable, it is often born with signs of retarded development, performing in an imperfect manner its vital functions, or else exhibiting well-marked signs of disease in an enlarged abdomen due to ascites, to enlarged liver or spleen, with nodes in the lungs or in the bronchial glands, with hydrocephalus, separation of the epiphyses of the long bones from the diaphyses, with extensive pemphigoid eruptions on the skin, or perhaps presenting a deformed or monstrous appearance. There are cases, however, in which the course of intra-uterine life does not seem to be influenced in the slightest degree by syphilis. The children are born apparently healthy and well-developed, but exhibit well-marked signs of their hereditary taint within the first few weeks after birth.

Treatment.—The treatment of fœtal syphilis will be usually preventive, and must consist in an effort to improve the building material of which the future embryo will be constructed by eradicating the disease, by a thorough course of antisyphilitic treatment, from one or both parents. Should it be clear that the fœtus derives its syphilis from one parent alone, while the other remains healthy, then of course treatment of the healthy individual would be superfluous; but in case of the slightest doubt it would be prudent to administer to both man and woman the appropriate remedies.

Should a pregnant woman come under the observation of a physician with the history that she was with child by a syphilitic man, although healthy herself, or that she had acquired a chancre subsequent to conception, it would seem advisable to begin a course of mercurial treatment at once, not only with a view of improving the mother's condition, but with the reasonable hope of directly influencing the morbid processes that are possibly going on within the fœtus or its appendages; for, as Robolski[2] has shown that mercury administered in a soluble form to pregnant women may be found in the meconium and urine of their children immediately after birth, it is certain that the soluble salts of this drug will pass directly from the maternal into the fœtal circulation.

OTHER INFECTIOUS DISEASES OF THE FŒTUS.—As the infectious

[1] See the "Causes of Habitual Death of the Fœtus, and their Detection," p. 288.

[2] *Inaug. Dis.*, Halle, 1884.

diseases are dependent upon the entrance of certain low forms of life into the system for the characteristic group of symptoms that distinguish the respective affections of this class, it is impossible that they should directly affect the fœtus in utero, unless pathogenic micro-organisms are able to pass from the maternal blood through the utero-placental septum into the fœtal portion of the placenta.

But the views of competent observers as to the possibility of the passage of solid particles, no matter how minute, through the epithelial covering of the placental villi, stand at present diametrically opposed. On the one hand, the positive assertion is advanced, based upon experimental work, that the epithelial covering of the placenta offers an impermeable barrier to the passage of solid matter, while, on the other hand, one finds an equally positive declaration that the passage of such matter from the maternal circulation into the placenta has frequently been observed. Brauell[1] and Davaine,[2] experimenting with the bacillus of anthrax, saw large colonies of the micro-organism heaped up on the maternal side of the utero-placental septum, but failed absolutely to find a trace of them in the placenta or fœtus. Straus and Chamberland[3] failed to infect animals by injecting the blood of a fœtus taken from an animal that had died of anthrax. Runge of Dorpat inoculated a number of rabbits with tuberculosis, but failed absolutely to detect the characteristic bacillus in the fœtus. Chambrelent[4] quotes Budin, Tarnier, Charpentier, Hoffman, Jassinsky, and Fehling as denying the possibility of the passage of microbes from mother to fœtus. V. Ott,[5] in a recent article, after giving a résumé of the literature on the subject, expresses his disbelief in the passage of solid particles into the placenta, and supports his statement by describing experiments of his own which altered the constitution of the maternal blood without affecting that of the fœtus. Wolff[6] infected a number of pregnant rabbits and guinea-pigs with anthrax, and failed absolutely to find a trace of the disease in their young. Curt Jani,[7] an assistant of Prof. Weigert of Leipsic, having an opportunity to examine the body of a woman who had died in the fifth month of pregnancy from general miliary tuberculosis, found not a trace of the bacilli of tuberculosis in the placenta or fœtus, although every maternal organ was markedly affected. And Urvitch[8] inoculated seven pregnant mice with the microbes of mouse-septicæmia, which proving fatal to all of them, they were carefully examined, with the result of finding the specific micro-organisms in great quantities through the maternal tissues,

[1] *Virch. Archiv*, xiv. 1858, p. 459. [2] *Bulletin de l'Academie de Méd.*, 1867.
[3] *Comptes rendus de la Société de Biologie*, 1882, p. 689.
[4] *Recherches sur le Passage des Éléments figurés à travers le Placenta*, Paris, 1883.
[5] *Arch. f. Gyn.*, Bd. xxvii. [6] *Virch. Archiv*, 105, p. 192.
[7] *Ibid.*, 103, p. 522. [8] *Inaug. Dissertat.*, St. Petersburg, 1885, p. 77.

but entirely absent in the placenta and fœtus. Inoculations with the blood of the mother-animals were invariably fatal to other mice, while the fœtal blood was entirely inert. Finally, Bompiani[1] delivered a woman who was suffering from anthrax, but whose fœtus showed no sign of the disease.

But, on the other hand, not only microbes, but even small particles of colored substances like ultramarine blue and cinnabar, have been found in the placental and fœtal structures after they had been injected into the maternal tissues. In 1882, Arloing, Cornevin, and Thomas[2] showed the possibility of the passage of anthrax bacilli from mother to fœtus; and in the same year Straus and Chamberland, although they at first supported the views of Davaine and Brauell, finally changed their opinions and announced their belief in the transmissibility of contagious diseases to the fœtus in utero.[3] Chambrelent[4] also was able to cultivate the microbes of chicken cholera from the fœtal blood, and to reproduce the disease by inoculating an animal with the cultures. Mars[5] of Cracow found, after injecting putrid solutions into pregnant rabbits, not only in the maternal but also in the fœtal blood a great number of bacilli; and Dr. Pyle,[6] working in the pathological laboratory of the University of Pennsylvania under the superintendence of Dr. Formad, obtained practically the same results, not only in the lower animals, but, having an opportunity to examine the body of a human fœtus removed from its mother by Cæsarean section on account of her approaching death from septicæmia, he found vast numbers of micro-organisms in its blood. Finally, Koubassoff,[7] after experimenting under the supervision of Pasteur in his laboratory in Paris, claimed never to have failed to find the anthrax bacillus in the fœtus when the mother had been thoroughly infected with the disease, except in one instance, where of two fœtuses one was partially macerated and its placenta the seat of hemorrhagic extravasations, while the other was well developed. In the former of these two no bacilli were found, but in the latter they were present in large numbers. Upon this observation Koubassoff bases the conclusion that the placenta can only offer effective opposition to the passage of microbes when its condition is pathological. It seems difficult to come to a definite conclusion, in the face of such conflicting testimony, as to the passage of pathogenic micro-organisms from mother to fœtus; but, as there is no reason for doubting the positive assertion of those observers who declare that

[1] *Annali di Ostet.*, May–June, 1887.

[2] *Comptes rendus des Séances de l'Academie des Sciences*, 1882, xcii. p. 739.

[3] See Koubassoff: *Ibid.*, vol. c. p. 373.

[4] *Recherches sur le Passage des Éléments figurés à travers le Placenta*, Paris, 1883.

[5] Abstract by Chambrelent: *Arch. de Tocol.*, 1883, p. 381.

[6] *Med. News*, Aug. 30, 1884.

[7] *Loc. cit.*

they have actually demonstrated the possibility of such a migration by finding certain microbes in the fœtus after they had been injected into the maternal tissues, and as the list of diseases which depend for their existence upon the presence of specific micro-organisms, and which have in certain well-authenticated cases undoubtedly attacked the fœtus in utero, is already a long one, it seems necessary to admit that while the presence of pathogenic microbes in the maternal organisms by no means assures their presence in the fœtus, yet the possibility of their migration across the utero-placental septum must be conceded.

Variola.—The occurrence of variola during intra-uterine life has long been a fact beyond dispute, admitted even by the most zealous advocates of the theory that the placenta cannot be invaded by the germs of infectious diseases. Indeed, the fact that smallpox can attack the fœtus has been cited as an argument against the existence of a specific micro-organism for this disease. Very many cases are recorded in which a child marked with pustules was born of a mother who had been attacked with variola during pregnancy. But the susceptibility of the fœtus to the disease varies in a remarkable manner. No doubt, as Tarnier[1] says, in the majority of cases the fœtus manifests no signs of the disease even though the mother be seriously affected, but the mother may have only varioloid and yet the child be born with the marks of smallpox on it;[2] or, still more remarkable, the mother, having been exposed to the contagion of smallpox, but having shown no sign of the disease, may give birth to a child covered with pustules.[3] Again, it has been noted that, of twins, one or both of the children may be affected.[4] The fact that smallpox can attack the fœtus has led many observers to test the possibility of an intra-uterine vaccination, with the result that *a priori* might have been predicted. While in the majority of cases the attempt to give the fœtus an immunity against an attack of smallpox after birth by vaccinating the pregnant woman has been a failure, in a few instances it has been successful. For example, Behm[5] vaccinated 33 women, and of their children, 25 were successfully vaccinated after birth. Wolff[6] says that he has repeatedly vaccinated pregnant women, and has never failed to successfully vaccinate their offspring. Ridgen[7] tells of 8 cases of smallpox occurring in pregnant women in whose children, born alive, a subsequent vaccination "took." On the other hand, Desnos[8] and Chambrelent[9] each

[1] Tarnier et Budin: *Traité des Accouch.*, vol. ii. p. 14.

[2] Charcot: *Comptes rendus de la Société de Biologie*, 1851, p. 39, and 1853, p. 88; Chaigneau: *Thèse de Paris*, 1847; Chantreuil: *Gaz. des Hôpitaux*, 1870.

[3] Laurent: *Lyon Médicale*, 1884, June 15.

[4] *Obstet. Trans. London*, vol. iii. p. 173.

[5] *Zeitschr. f. Geburt.*, Bd. vii. p. 1.

[6] *Virch. Arch.*, Bd. cv. p. 192.

[7] *Br. Med. Journ.*, 1877, i. p. 229.

[8] *Société méd. des Hôpitaux*, 1871 (see Tarnier et Budin, *op. cit.*, p. 13).

[9] *Loc. cit.*, p. 385.

relate a case in which vaccination was several times unsuccessfully performed upon children whose mothers had shortly before their delivery recovered from an attack of smallpox. Chambrelent, moreover, vaccinated 7 pregnant women, but of their children he was able to successfully vaccinate only 3. Precisely, therefore, as smallpox can affect the fœtus in utero, but does not, as a rule, so can the fœtus in utero in exceptional cases acquire an immunity from smallpox by the vaccination of its mother—an occurrence, however, of such uncertainty as not to justify the neglect to vaccinate also the newborn infant.

Measles.—The transmission of the poison of measles from the mother to the fœtus is undoubtedly a rare occurrence, but there are, nevertheless, certain well-authenticated cases on record of children born with a rubeolous rash upon them: Thomas[1] was able to collect 6 such cases from medical literature. There are also cases recorded of measles appearing in the first few days of extra-uterine life, making it probable, from the short period of incubation, that infection had occurred in utero.

Scarlatina.—More than one eminent authority has expressed a doubt as to the occurrence of scarlet fever in utero, but the evidence, although scanty, is conclusive that on rare occasions children have been born with a well-marked scarlatinous rash upon them. Dr. Leale[2] of New York describes a case in his own practice in which a boy was born at the beginning of a well-marked attack of scarlet fever in the mother which she had contracted from an older child. The newborn infant presented a dark, congested red hue and a characteristic raspberry tongue. The eruption lasted seven days, and desquamation began on the tenth day, at which time the albuminous urine and general anasarca pointed to a desquamative nephritis. This child recovered. Dr. Leale was, moreover, able to collect a number of cases recorded by Hüter, Meynet, Asmus, Baillou, Tourtual, Gregory, and Stichel. Dr. Wilson Saffin[3] of Carthage, Ohio, has also reported a very interesting case of scarlet fever in utero: A lady who had had scarlet fever in childhood was nursing her child through the disease while she herself was in the last month of pregnancy. She was not affected by the disease, but complained of a bad sore throat. Two weeks afterward she was delivered of a male child with a typical scarlet rash upon it; the disease ran a course of nine days, with desquamation in large and small flakes, beginning on the fifth day. The infant's temperature ranged from 100°–104° Fahr., and the attack ended in recovery. In this case the mother, without contracting scarlet fever herself, had nevertheless transmitted the disease to her child in utero.

[1] *Ziemssen's Handbook*, vol. ii. p. 50 (see also Underhill, *Obstet. Journ. Great Britain and Ireland*, 1880, p. 385, and MacDonald, *Edin. Med. Journ.*, 1884–85, 699).

[2] *Medical News*, 1884, p. 636.

[3] *N. Y. Med. Record*, April 24, 1886.

Erysipelas.—Kaltenbach[1] in 1884 observed a child, born of a woman who had had erysipelas in the last month of pregnancy, that a few days after birth shed its skin as if it had had an attack of erysipelas in utero. Runge[2] of Dorpat and Stratz[3] have described similar cases, but Tarnier[4] calls attention to the fact that desquamation in the healthy newborn infant is not such an uncommon occurrence. Lebedeff,[5] however, has presented convincing evidence as to the possibility of intra-uterine erysipelas in the following case: The child of a woman delivered at the seventh month in the midst of an attack of erysipelas presented alternate patches of red and white on its skin at birth; it lived ten minutes: after death Fehleisen's micrococcus was found in the subcutaneous adipose tissue, was cultivated, and rabbits inoculated with the cultures acquired the disease. No microbes, however, were found in the placenta or cord. Lebedeff believes that the specific microbes entered the placenta through a villus deprived of epithelium (Langhans).

Malaria.—The same difference of opinion that is met with as to the existence of many other diseases of the fœtus in utero is encountered in the study of congenital malaria. Among others, Burdel[6] expresses his disbelief in the existence of congenital malaria, and Tarnier quotes Leroux as saying that "as yet it is impossible to say positively that congenital malaria exists;"[7] but the testimony as to the occurrence of symptoms of disturbance in the unborn fœtus at regular intervals corresponding or not to the attacks in the mother, and the manifestations of periodical seizures beginning immediately after birth, is quite voluminous and of a credible character. Behrmann relates[8] two cases of intra-uterine infection in which the disease manifested itself directly after birth. Dr. W. T. Taylor of Philadelphia presented to the Philadelphia Obstetrical Society the history of a lady who, having lived during the last months in a malarial locality, moved to a healthy situation to be delivered. The nurse noticed that the newborn child was seized with attacks of restlessness during the first week of extra-uterine life, and evident discomfort at a certain period during the day. As a malarial origin of the attacks was suspected, quinine was administered to the mother, and in a short time the infant became healthy. Dr. Harris at the same time described a similar case yielding to the same treatment.

Aside, however, from the direct action of the malarial poison upon the fœtus in utero, the existence of malaria in the mother seems to have a deleterious influence on its growth and development. Thus,

[1] *Centralb. f. Gyn.*, No. 44, 1884.
[2] *Centralb. f. Gyn.*, No. 48, 1884.
[3] *Centralb. f. Gyn.*, ix. 213.
[4] *Loc. cit.*
[5] *Zeitschr. f. Geburt.*, xii. 2, p. 321.
[6] *Annales de Gyn.*, viii. p. 31.
[7] *Op. cit.*, p. 24.
[8] *Berlin. klin. Wochenschr.*, 1885, Aug. 24, Sept. 7.

Bompiani[1] says that the children born of malarial mothers very rarely reach 3250 gm. in weight or 50 cm. in length, and Negri[2] observed 34 cases in pregnant women, of which 18 per cent. terminated by premature expulsion of the fœtus, which was in two instances macerated. The administration of quinine in large doses to the mother affected with malaria would therefore be called for, and one need not be deterred from employing the drug by the fear that once prevailed of so bringing on an abortion, for, as Tarnier says, "quinine, in this condition, is the best prophylactic treatment against abortion or premature labor."

Tuberculosis.—Considering the very large number of tuberculous women who become pregnant, it is an extraordinary fact that the direct transmission of the disease from the mother to the fœtus is an extremely rare occurrence. Runge[3] of Dorpat infected a number of pregnant guinea-pigs with tuberculosis, but invariably failed to find the characteristic bacilli in the fœtal tissues or placenta. Ballinger, Davaine, Brauell, and Wolff have all expressed a decided disbelief in the existence of congenital tuberculosis, and Jani's observations have already been referred to. But Demme once found the tubercle bacillus in the macerated fœtus of a tuberculous woman, and on one occasion Johne[4] discovered tubercles in a stillborn calf, in which he found the bacillus tuberculosis. While, therefore, there is a remote possibility of the passage of tubercle bacilli from mother to fœtus, it must be regarded as a very exceptional occurrence.

Septicæmia.—The possibility of the transmission of septic micro-organisms from mother to fœtus has been denied by many, but the occurrence of septic infection of the fœtus in utero has been strongly affirmed by Koubassoff, Chambrelent, Pyle, Mars, H. v. Holst, and others. Mars[5] of Cracow injected putrid solutions into pregnant animals, and found often the same bacilli in mother and fœtus. Dr. Pyle's observation on the body of a fœtus removed by Cæsarean section from its mother, who was dying of septicæmia, has already been noticed; and, finally, Von Holst,[6] after an extensive search through medical literature, asserts positively that, although intra-uterine septic infection of the fœtus is rare, it has undoubtedly occurred.

Cholera.—Tarnier[7] says that there is nothing to justify the belief that cholera affects directly the fœtus in utero; and Queirel[8] asserts that it is doubtful whether cholera can be conveyed to the fœtus in utero, but, nevertheless, early abortion is the rule, and if the child should be born near or at term it dies in a few days.

[1] *Annal. di Ostet.*, vi. 42, 46, 1884.
[2] *Ibid.*, viii. p. 277.
[3] Quoted by v. Ott, *loc. cit.*
[4] Quoted by Wolff, *loc. cit.*
[5] *Abstract Arch. de Tocol.*, 1883, p. 380.
[6] *Dissertation*, Dorpat, 1884; *Abstract Centralb. f. Gyn.*, 1885, p. 200.
[7] *Loc. cit.*
[8] *Nouv. Arch. d'Obstét. et de Gynéc.*, April 25, 1887, p. 1.

Typhoid Fever.—The effect upon the fœtus of typhoid fever in the mother is, as a rule, disastrous, resulting in the expulsion of the product of conception in about 65 per cent. of the cases,[1] "the elevation of the temperature, the alteration of the blood, and the respiratory embarrassment" (Tarnier) being considered the causes of the abortion or premature labor. But that the disease can affect the fœtus itself has been shown by Neuhaus,[2] who found Ebert's rods, the specific bacilli of typhoid fever, in the lungs, spleen, and kidneys of a fœtus expelled at the fourth month from a woman who was convalescing after a prolonged attack of typhoid fever.

Articular Rheumatism.—The consideration of this disease among the infectious diseases is perhaps not yet entirely justifiable. There are, however, two instances on record of the transmission of the disease from mother to fœtus—one described by Pocock,[3] the other by Schaeffer.[4] In each a woman affected with articular rheumatism at the end of pregnancy gave birth to a child presenting in one case at once, in the other at the end of three days, unmistakable evidence of being affected with the same disease.

Recurrent Fever.—Albrecht[5] has described three cases of congenital recurrent fever, and in the blood of one fœtus he discovered the spirilla.

Yellow Fever.—Dr. Bemiss[6] of New Orleans says: "The pregnant woman being attacked by yellow fever and recovering without miscarriage, immunity from future attacks is conferred upon the offspring contained in the womb during the attack." If this is true, it certainly seems that the fœtus must have likewise passed through an attack of the disease.

Summarizing, now, the evidence in regard to the passage of pathogenic micro-organisms from mother to fœtus, and finding so many well-authenticated cases of fœtal infection by diseases depending upon a specific living virus for their characteristic manifestations, it seems necessary to admit the possibility of a migration of such microbes from the maternal blood into the placenta. But, at the same time, it must be conceded that such an occurrence is rather exceptional, and that it is impossible to admit the truth of Koubassoff's dictum, that a failure on the part of the microbes to pass the utero-placental septum indicates a pathological condition of the placenta. Whether, on the other hand, Lebedeff's theory is true, that it is only possible for microbes to enter the placenta through a villus that is deprived of its epithelial covering, must as yet remain in doubt.

Non-Infectious Diseases of the Fœtus.—The diseases that

[1] Duguyot: *Thèse de Paris*, 1879.
[2] *Berlin. klin. Wochenschr.*, 1886, p. 389.
[3] *London Lancet*, 1882, ii. p. 804.
[4] *Berlin. klin. Wochenschr.*, 1886, S. 79.
[5] *St. Petersburg med. Woch.*, 1880, No. 18, u. 1884, p. 129.
[6] See Parvin's *Obstetrics*, p. 222.

have been considered have their origin in the maternal organism, and in each instance a specific *materies morbi* is transmitted to the fœtus; but there is another class of morbid processes having an independent origin in the fœtus itself, and not directly dependent upon a pre-existing disease of a like nature in the mother, although no doubt the predisposing, and even the exciting, causes are often to be found in the malnutritive condition of the maternal blood or in some morbid nervous action. So close occasionally is the apparent connection between a disease of the mother and a similar affection of the fœtus that the belief in the transmission from one to the other seems at first unavoidable. So, for instance, in that interesting case described by Dohrn[1] of a mother affected in the last weeks of pregnancy with purpura hæmorrhagica giving birth to a child presenting numberless subcutaneous hemorrhagic extravasations, the fœtal disease seemed to be directly derived from the maternal affection. Here, however, the woman being miserably poor and badly nourished, and her blood consequently being insufficient in nutritive qualities, the same cause naturally produced the disease in mother and child. So, again, in the following case, related by Strachan,[2] the disease might at first seem to have been transmitted from mother to fœtus: A woman in the eighth month of pregnancy was admitted to a hospital ward on account of acute pneumonia of the left lung. Shortly afterward she gave birth to a child that lived only a few hours, and which after death was found to have also acute pneumonic consolidation of the left lung.[3] But the ingenious explanation of Geyl,[4] who has observed several undoubted cases of acute pneumonia in utero, is no doubt correct. In these cases there has been some interference with the oxygenation of the fœtal blood, and the resulting asphyxia has induced efforts at respiration, whereby amniotic fluid has been drawn into the lungs and there set up an inflammation.

Notwithstanding our very scanty knowledge of the pathology of intra-uterine life, the list of diseases which are at present under consideration is already an astonishingly long one. They may be said in some instances to owe their origin to a vitiated condition of the maternal blood, or to be due to inherent weakness in the building material of the fœtus, as in cases of chronic systemic affections of either parent, or to be caused by perverted nervous action in the mother; while there are still others for which a cause is unassignable. Some of these affections may be passed by with a simple mention. Such are inflammations of the serous membranes,[5] and the resulting ascites, hydrothorax,

[1] *Arch. f. Gynäk.*, Bd. vi. S. 486. [2] *Br. Med. Journ.*, 1886, ii. p. 860.

[3] The author has reported a case of pneumonia in utero in the *Am. Journ. Obstet.*, Nov., 1887 (Tr. Philada. Obstet. Soc.).

[4] *Arch. für Gynäk.*, Bd. xv. 384.

[5] For a reference to endo- and pericarditis see Cruveilhier, quoted in *Ann. di*

hydrocephalus, due in the majority of cases to syphilis, although there is one case[1] on record of atresia vulvæ et recti and a vesico-uterine and utero-rectal fistula, where the urine escaped into the peritoneal cavity through the Fallopian tubes and set up a violent peritonitis; certain skin diseases, as ichthyosis, alopecia, hypertrichosis, albinism, purpura hæmorrhagica, and elephantiasis;[2] intra-uterine brain disease,[3] which may consist in sclerosis, atrophy, lack of development, tumors, cysts, or inflammation of the membranes, diseases of the liver, sclerotic or multicystic,[4] along with cystic disease or cirrhosis of the kidneys and the many varieties of congenital tumors, solid or cystic, malignant or benign, which are better described in text-books on pathology or surgery, or in connection with the study of dystocia. In addition to these affections, however, that have been so hastily passed over, there are others deserving more consideration.

Fig. 181.

Intra-uterine Rachitis (Tarnier et Budin).

Rachitis.—That this disease affects the fœtus in utero there is the most abundant evidence. Children have been born with the rachitic processes in their most active stage; that is, while the bones are still soft and easily distortable, or at birth, the process has evidently pursued a longer course, for the bones are abnormally hard and thick, and set in the deformed shapes that they have acquired in utero.

Schorlau[5] collected the records of 43 cases of congenital rachitis, and added to the number 2 of his own; while Gräfe[6] mentions the cases that have been described by Sandefort, Winckler, Schultz, Virchow, Kehm, and Fischer; and of late years Fehling[7] and Hennig[8] have also described specimens of fœtal rachitis.

As the etiology of infantile rachitis is by no means clear, it is all the more difficult to explain the occurrence of rachitis in utero. It may be said, however, to depend upon some vice of nutrition, especially if the

Obstet., July, Aug., 1887, p. 314; and for congenital valvular defect, diagnosticated before birth, see *Tr. Med. and Chir. Fac. Maryland*, 1884.

[1] Olshausen: *Arch. f. Gynäk.*, Bd. ii. S. 280.

[2] Duhring: *Diseases of the Skin*, p. 418.

[3] *London Lancet*, 1886, i. p. 220.

[4] *Tr. London Path. Soc.*, vol. vii. pp. 229, 235.

[5] *Monatschr. f. Geburtsh.*, Bd. xxx. S. 401.

[6] *Arch. f. Gyn.*, Bd. viii. S. 500.

[7] *Ibid.*, Bd. x.

[8] *Transactions of Meeting of German Naturalists and Physicians*, Berlin, 1886.

pregnant woman is living under unfavorable conditions as to food, light, and ventilation; but the fact that the mother has at some time had rachitis herself, as evidenced by the shape of her pelvis, seems of itself by no means to predispose the fœtus to the same affection. The appearance of a rachitic fœtus, especially in the higher grades of the disease, is quite distinctive. Such a fœtus will show an enlarged head, perhaps hydrocephalic, gaping sutures and fontanelles, a "pigeon" breast, a much-distended abdomen, the extremities short, thick, and often bent at an angle or curved, and the joints large and prominent. The spine will often be curved either laterally or antero-posteriorly.[1] The bones will be either abnormally hard and firm, or, on the other hand, the medullary spaces of the long bones may so encroach upon the hard bony tissue as to be covered with a very thin layer of bone, which will be fractured by the use of the slightest force. This condition of the bones in rachitis may be simulated by the arrest of bony development in those cases of fœtal cretinism[2] occasionally met with in Europe.

Anasarca.—General anasarca of the fœtus, occurring perhaps in conjunction with anasarca of the mother, but more frequently associated with no apparent maternal affection, is occasionally seen. The distension of the fœtal skin may reach such dimensions that the expulsion of the child becomes exceedingly difficult.[3] Such children are, however, usually born prematurely from the fourth to the eighth month, and are, as a rule, stillborn, although cases are recorded in which death only occurred some little time after birth. The causes of this condition must be various. It has been attributed to anasarca of the mother, to syphilis—in one instance to leukæmia of the fœtus,[4] in another to obstruction of the umbilical vein;[5] and Steinwirke[6] describes a case under the name of elephantiasis congenita cystica. The serous infiltration of the skin is usually accompanied by a collection of fluid in the abdominal and pleural cavities, and the membranes and placenta are often markedly œdematous.

Spontaneous Fractures in Utero.—The fœtal bones may be broken by external violence, or a child may be born presenting numerous fractures, especially of the long bones, either recent or already undergoing repair, without the history of an accident of any kind to the mother during pregnancy. If in such cases one can exclude a syphilitic osteo-chondritis with a separation of the epiphysis and diaphysis, or an injury to the child during labor, there must have been a rachitic condition of the bones or an arrest of ossification to allow of fracture by the slight force

[1] Gräfe, *loc. cit.*

[2] *Virchow's Arch.*, Bd c. S. 256.

[3] Keiller: *Edinb. Med. and Surg. Journ.*, April, 1855.

[4] Klebs: *Prag. med. Wochenschr.*, 1878, No. 49.

[5] *Breslauer Klin.*, Bd. i. S. 260.

[6] *Dissertat.*, Halle, 1872.

which could be exerted by the fœtal muscles or the pressure of the uterine walls. Link,[1] however, describes a case of numerous fractures in utero of the ribs, clavicle, and extremities in which syphilis, rachitis, and chronic parenchymatous osteitis could be excluded, and he therefore concludes that these fractures were caused by an "unknown intra-uterine fœtal bone disease," in which the bones became soft and brittle.

Luxations and Ankyloses.—These affections of the joints are interesting—the first to the surgeon, the second in connection with the study of dystocia. It is interesting to note that luxations affect females four times as often as males,[2] and are much more common in the lower than in the upper extremities. An apparent ankylosis[3] after birth occasionally appears when in breech presentations the presenting part has remained a long time in the cavity of the pelvis. In these children the lower limbs remain in the position—of flexion of thighs upon abdomen and extension of legs upon the thighs—that they occupied in utero, and it is impossible for a while to restore them to a proper position.[4]

Intestinal Invagination.—Lauro[5] has very recently described a double invagination of the descending colon during intra-uterine life.

Intra-uterine Amputations.—The complete severance of a portion of a limb from its connection with the body of the fœtus in utero is an extremely rare occurrence, but one which has been often enough described—in many instances no doubt in mistake for some form of ectromelic monstrosity. There are, however, at present a number of undoubted cases on record.[6] The explanation of this affection is most frequently to be sought in the presence of constricting amniotic bands—a condition more fully discussed under the pathology of the amnion—but this explanation will not suffice for all cases; for it has been demonstrated that a gangrenous process[7] at a certain point in the limb may determine an amputation, just as it would in extra-uterine life, or that a peculiar morbid process[8] may produce a constriction from the circular contraction of connective tissue at a certain point, or, again, that an amputation[9] may follow a fracture. The amputated part may float loose in the amniotic liquid, may possibly be absorbed if detached early

[1] *Archiv für Gynäk.*, Bd. xxx. 2, p. 264, 1887. [2] Tarnier et Budin: *loc. cit.*

[3] Lefour: *Presentation du Siège décomplété Mode des Fesses*, Paris, 1882.

[4] The fixation of the limbs or trunk in abnormal positions by muscular contraction may occur in utero during pregnancy, as in that interesting case of "contracture" in utero (Ribemont-Dessaigne, abstract in *Nouv. Archiv. d'Obstét.*, Sept., 1887). In this connection the student should consult also the paper by Matthews Duncan on "Extensions and Retroflexions of the Fœtus, especially of the Trunk, during Pregnancy" (*Trans. London Obstet. Soc.*, xxvi., 1884, p. 206).

[5] *Annali di Ostet. e Ginecol.*, Luglio-Agosto, 1887.

[6] For an extensive bibliography see Tarnier et Budin.

[7] Chaussier: *Procès verbal de la Distribution des Prixes à la Maternité*, 1822.

[8] Kristeller: *Monatsch. f. Geburt.*, Bd. xiv. p. 817.

[9] Martin: *Gaz. hébdom.*, 1858, p. 384.

in embryonal life, or may be attached to the sound portion of the limb by a filament more or less bony (Tarnier et Budin).

Fœtal Traumatism.

The position of the fœtus in utero is one that secures it the greatest possible immunity from external violence, surrounded as it is by liquid, protected by the soft and flexible uterine muscles, and further shielded by the fatty, muscular, and cutaneous tissues that form the abdominal walls; but, in spite of this evident attempt of Nature to afford it every protection, the fœtus can experience injuries of the gravest nature, either in connection with serious injury to the mother, or occasionally with very slight evidences of violence to the maternal tissues. Thus in cases of gunshot,[1] stab,[2] or other perforating wounds of the abdomen in pregnant women, the fœtus has likewise been severely and fatally wounded. Also, in the performance of laparotomy[3] by a mistaken diagnosis the trocar that was plunged into what was thought to be an ovarian cyst has penetrated the fœtus, and wounds have been inflicted by both sharp and dull instruments ignorantly used to bring on an abortion or in the hands of physicians who overlooked the condition of pregnancy (Tarnier et Budin). On the other hand, as instances of fatal injury to the fœtus without apparent injury, externally at least, to the mother, might be cited those interesting cases of Maseka[4] and Gurlt,[5] in which the cranial bones of the fœtus were fractured by the mother falling from a height, or the still more remarkable case described by G. von Hoffmann[6] of a woman in the fifth month of pregnancy who threw herself out of a fourth-story window, and was killed by the fall, although she exhibited no signs of external injury: the uterus was uninjured, and the fœtus externally was apparently unharmed, but on opening its abdomen the liver was found to be almost disintegrated. The case, however, reported by Dr. Lumney[7] shows more clearly how a slight violence to the mother may be fatal to the fœtus: A pregnant woman, within ten days of term, attempting to enter a doorway, slipped and struck the left lower portion of her abdomen against the edge of the door. The movements of the child thereupon ceased, and eight days afterward a dead fœtus was born with a fracture of the left frontal and parietal bones of the skull.

These cases of fœtal injury are not only interesting from their rarity,

[1] Hays: *Ann. de Gyn.*, 1880, xiii. p. 153.

[2] Fennell: *Tr. N. Y. Path. Soc.*, iii. 249; Tarnier et Budin, *loc. cit.*, p. 315; Guelliot: *Gaz. des Hôp.*, 1886, p. 405.

[3] Goodell: *Lessons in Gynecology*, p. 352.

[4] *Prager Vierteljahrschrift*, 1857.

[5] *Monatsch. f. Geburt.*, 1857, p. 343.

[6] *Wien. med. Presse*, xxvi., 1885, Nos. 18, 20, etc.

[7] *N. Y. Med. Rec.*, 1886, p. 359.

but they are also important from a medico-legal point of view. Thus, Gorhan[1] records the death of a fœtus from violence done the mother at the hands of another woman in the course of a brutal quarrel between two sisters-in-law, during which the pregnant woman, being at the time in the sixth month of gestation, was thrown to the ground and stamped upon by her infuriated relative. Two months afterward a dead fœtus was born, corresponding in development to the sixth month of pregnancy, and exhibiting a transverse fracture of both parietal bones. It might also be of great importance to distinguish injuries experienced during labor, as fractures of the extremities, spine,[2] or skull (löffel-[3] oder rinnen förmiger Eindruck), from the effects of traumatism during pregnancy, as well as from the spontaneous fractures of bones in utero. There should be no difficulty in making the distinction—on the one hand, by the history, and, on the other, by the multiple nature, of the apparent injury which is usually found in spontaneous fractures and by the evidence of disease in the bones.

Conditions of the Mother which Injuriously Affect the Fœtus.

Bearing in mind the absolute dependence of the fœtus in utero upon the maternal structures for the performance of its most important vital functions, it is not difficult to realize the ease with which any disturbance of the maternal economy will react injuriously upon the fœtus. Not only may this unfavorable influence be exerted by certain abnormal physical conditions, as alterations in the quality or quantity of the blood, modifications in the blood-current, or varying degrees of blood-pressure,[4] and changes in the maternal temperature, but also by certain morbid psychical states, as strong emotions, which, in spite of the fact that there is no demonstrable nervous connection between mother and fœtus, exert often a powerful influence upon the latter's growth or well-being—a phenomenon to be explained perhaps by some alteration of the maternal blood that may be produced by a powerful nervous action, as an electrical current can decompose a chemical solution, although there is no definite knowledge as yet of what this change is. The extraordinary effect, however, that powerful emotions in nursing-women have upon their milk, converting it into a rank poison for their offspring, would tend to support this view.

The Influence of High Temperature upon the Fœtus.—The well-

[1] *Wien. med. Presse*, xxvi. p. 370.

[2] J. Taber Johnson: *Tr. Am. Gyn. Soc.*, vol. iii. p. 107.

[3] There are, however, two recorded cases of this injury occurring from traumatism during pregnancy.

[4] Runge: *Arch. f. Gyn.*, Bd. xiii. p. 488.

known experiments of Runge,[1] published in 1877, were for some time accepted as conclusive proof of the great danger to the fœtus of high temperature in the mother. Pregnant rabbits placed in a hot box until their body-temperature had risen to 105.8° usually died, but almost invariably the fœtuses were found dead upon opening the animal's body immediately after its removal from the box. But in 1883, Doléris[2] showed that if the temperature of the animals was slowly raised to 105°–106°, and not within an hour, as in Runge's experiments, they seemed to bear it without much inconvenience, even if long continued, and, if pregnant, their young remained perfectly healthy. These results were confirmed by Runge[3] in a second set of experiments, in which he found, however, that if the animal's temperature was raised, even very gradually, to 109.4°, there occurred the same symptoms—death of the fœtus and heat-stroke of the mother—as if the temperature had been quickly raised to 106°. Preyer[4] has also shown that the fœtus is capable of enduring a much higher temperature than was formerly supposed, for in one instance he actually observed a fœtal temperature, in a guinea-pig, of 111.2°, taken in ano, the fœtus living nine minutes, or until the cord was severed and it was removed from the uterus. In view, therefore, of these recent experiments, it seems necessary to modify the views formerly entertained that the existence of fever in the mother of itself must necessarily threaten the life of the fœtus, unless, indeed, the temperature should rise suddenly, as in the case of brain tumor described by Runge, or in those cases of recurrent fever recorded by Kaminski,[5] or else should reach an extreme height, as it might in insolation.

As to the treatment of fever in pregnant women with a view to its influence on the fœtus, no special measures would be required as long as the temperature rose gradually and remained under 105°, but above this point the danger to the fœtus would begin (Kaminski), and active antipyretic treatment would be required. Should a pregnant woman die with a temperature as high as 109°, the performance of post-mortem Cæsarean section would be useless, for the fœtus would inevitably die first, having no means of getting rid of its extra heat by radiation. The operation would likewise be fruitless in a case of death after a very sudden rise of temperature (Runge).

The Influence of Maternal Emotions upon the Fœtus.—That either the ovule or the spermatic particle may be impressed with the peculi-

[1] *Arch. f. Gyn.*, Bd. xii. p. 16; Bd. xiii. p. 123.

[2] *Comptes rend. hébd. Séances de la Société de Biologie*, Nos. 28, 29. Doléris' results were confirmed by experiments of Doré (*Arch. de Tocol.*, 1884, p. 141), and quite recently by Negri (see abstract in *Nouv. Arch. d'Obstét. et de Gynéc.*).

[3] *Arch. f. Gyn.*, Bd. xxv. S. 1.

[4] *Physiologie des Embryo*, Leipzig, 1884.

[5] *St. Petersburg med. Zeitung*, 1868, S. 117.

arities, both mental and physical, of the respective individuals from whom they come, no one will deny. And it is equally true that no one can explain the nature of the influence exerted upon, say, a spermatic particle, which will manifest itself perhaps only in the adult life of the individual resulting from the fertilizing action of that spermatozoon, as is the case in hereditary criminal tendencies, in hereditary diseases appearing late in life, or in certain physical peculiarities manifesting themselves after puberty, as, for instance, the enormous moustaches that distinguish the male members of the present reigning house of Italy. But that maternal emotions and impressions are capable of affecting the embryo or fœtus after conception has occurred is by no means generally admitted—is, in fact, by some authorities strenuously denied. Many cases of mental peculiarities or diseases, or of physical defects, that have been attributed to a strong impression upon the mother during pregnancy are no doubt to be explained by the existence of some systemic disease, as syphilis, nephritis, diabetes, cancer, or chronic lead-poisoning in either father or mother, or in the case of intra-uterine amputations by the formation of amniotic bands or the disposition of the cord; but there still remain well-authenticated cases of congenital defects or peculiarities[1] which bear too startling a resemblance to the cause of the impression upon the mother during pregnancy to be dismissed as mere coincidences. The following case[2] may serve as an illustration of the class: A woman was delivered at the seventh month of pregnancy of a dead child which appeared to have no neck. Before showing her the child the attending physician asked her if she had noticed anything remarkable during her pregnancy, when the woman replied that during the first few weeks after conception she had looked into a medical book, and had there seen a picture of a child with the head set directly upon the shoulders—a circumstance which made a decided impression upon her, and one that had caused her considerable uneasiness ever since, for fear her child might be similarly deformed.

During my term of service at the Philadelphia Hospital there occurred the following case: An Italian woman, ætat. circ. 30, was brought to the obstetrical ward with a large lumbar abscess opening to the right of the spinal column, from which she had been suffering for a year. She was in the sixth to seventh month of pregnancy. After suffering severe pain for some weeks, which required the administration of morphia hypodermatically, she gave birth to a child weighing about four pounds, which had a deeply-congested mark on its back corresponding to the position of the opening of the abscess upon the back of the mother, and upon the infant's arm and forearm were sim-

[1] See the very interesting paper by Dr. Fordyce Barker in *Gynecol. Trans.*, vol. xi., 1886.

[2] Letter from Mr. Brydon of Hawick to *Brit. Med. Journ.*, 1886, i. 142.

ilar spots in the position corresponding to the points upon the mother's arm where it had been customary to administer the hypodermatic injections.

It would seem also that a strong emotion on the part of the mother may even be immediately fatal to the fœtus, as apparently happened in a case reported by Hayes.[1]

If there might be a reasonable doubt that the maternal blood may be altered in some unknown manner by a powerful nervous action, there is no question that certain maternal conditions can so modify the blood in its capacity of a bearer of oxygen and nutriment to the fœtus as to seriously interfere with the latter's health, if not to destroy its existence. Such is undoubtedly the case in pneumonia of the mother, which can prevent a proper aëration of the maternal, and consequently of the fœtal, blood, and may so bring about complete asphyxia of the fœtus, or may perhaps result in inspiratory efforts in utero, the inspiration of liquor amnii, and a subsequent development of pneumonia in the fœtus itself.[2] Whatever the cause of death, pneumonia in the mother is exceedingly fatal to the fœtus.

In infectious diseases also the development of specific micro-organisms in the maternal blood may so alter its normal constitution as to render it unfit for the respiratory and nutritive needs of the fœtus, this condition of the blood constituting perhaps the chief peril for the fœtus, for "the fever is usually the least of the dangers to the fœtus in these (infectious) diseases" (Runge). The occurrence also of exanthematous and hemorrhagic endometritis during the course of certain infectious diseases will be considered under the head of Decidual Endometritis.

Icterus Gravidarum in its Influence on the Fœtus.—The occurrence of this comparatively rare disease endangers to a high degree the life of the fœtus, either by bringing on an abortion or by first destroying the life of the fœtus through the poisonous action of the bile-salts,[3] or perhaps by the induction of cholæmic convulsions.[4] Thus, Spaeth[5] describes 8 cases, in 4 of which the fœtus was born dead; and Frerichs[6] mentions 3 cases, all fatal to the fœtus. Saint Vel[7] has described an epidemic of jaundice on the island of Martinique, during which, of 30 pregnant women affected, 20 were delivered prematurely, and of these 20 children, 19 were either stillborn or died shortly after birth. Bardinet[8] has also recorded the birth of 6 dead infants out of 13 pregnant

[1] *Lancet*, vol. ii., 1874.
[2] See page 281, this volume.
[3] Valenta: *Œsterreichische Jahrb.*, xviii., 1869, S. 163.
[4] Stumpf: *Arch. f. Gyn.*, Bd. xxviii. H. 3.
[5] *Wiener med. Wochenschr.*, 1854, S. 757.
[6] *Klinik der Leberkrankheiten*, 1858, Bd. i.
[7] *Gaz. des Hôp.*, 1862, p. 538.
[8] *Union Médicale*, 1863, Nos. 133 et 134.

women who were suffering from jaundice during an epidemic of the disease in Limoges. Frequently as the bile-salts must traverse the utero-placental septum and enter the fœtal circulation, as evidenced by the high percentage of stillborn children in women affected with jaundice during pregnancy, the coloring-matter of the bile seldom stains the fœtal tissues. Lomer[1] collected 56 cases in which naturally-colored children were born of jaundiced mothers, and 43 more in which the color of the child was not mentioned, so that it was presumably natural; and to these might be added another case described by Parrish. There are 6 recorded cases, however, in which the fœtus or the whole ovum was undoubtedly jaundiced (Lomer).

Eclampsia.—It has been estimated that about one-half the children are stillborn after the eclampsia of pregnancy or labor. The cause of the fœtal death is not altogether clear, for it might with equal plausibility be laid to the presence of too much carbonic oxide gas in the maternal blood, to the stagnation of the blood-current during a convulsion, or to the presence of urea or carbonate of ammonia in the blood.[2] As regards the safety of the fœtus, if it is viable a rapid delivery is indicated, although the measures taken to secure this end may, by their additional irritation, only aggravate the disease in the mother.

The Death of the Mother.—The effect of the death of the mother upon the fœtus is ultimately fatal of course, but as to the length of time that life can continue in the fœtus after it is extinct in the mother there is considerable difference of opinion. Disregarding the expressed view of Kergaredec, that twenty-four hours might elapse between the death of the mother and the fœtus, as preposterous, it is necessary to admit that there is on record a well-authenticated case of the extraction of a living child from the womb of a woman who had been dead two hours.[3] Tarnier[4] also performed post-mortem Cæsarean section upon a woman who during the Commune in Paris had been killed by a stray bullet in the wards of the Maternité, and extracted a living child, certainly three-quarters of an hour—perhaps an hour and a quarter—after the death of the mother. Numerous other instances are recorded of post-mortem Cæsarean operations or the extraction of infants *per vias naturales* at intervals of time ranging from a few minutes to a half hour after the death of the mother. To explain this remarkable survival of the fœtus under conditions which would seem to make life impossible it is sufficient to recall those cases of children born asphyxiated, whose hearts continue beating although they do not breathe for a long time after birth, or to recollect that experiment per-

[1] *Zeitschr. f. Geburt.*, xiii. p. 169, 1886.

[2] Perhaps also to the development of ptomaïnes in the blood (Doléris and Butte).

[3] Hubert: *Traité d'Accouchements*, vol. ii. p. 160.

[4] Tarnier et Budin, ii. p. 571.

formed by Haller[1] of forcing a bitch to give birth to her pups under water, where they crawled about and lived for half an hour.

THE DEATH OF THE FŒTUS.

The death of the fœtus in utero may be due to many causes. It may be the result of injuries, deformities, or diseases in the fœtus itself or in its appendages, the membranes and the placenta. It may be due to inherent weakness in either the ovule or the spermatic particle, which does not prevent conception, but which renders the embryo incapable of development beyond a certain point; or it may be the consequence of a misplaced ovum, as in tubal, ovarian, and abdominal pregnancies, or in those interesting cases of fœtus in fœtu, or of a fœtus enveloped by the placenta of its twin. The condition of the maternal blood, the existence of a very high temperature in the mother, and perhaps strong emotions, must also occasionally be held responsible for the destruction of fœtal life. All these conditions, however, have been or will be considered in their appropriate places; but it remains to notice the effect that the death of the fœtus produces upon the mother, the signs by which it may be possible to determine whether the fœtus in utero be alive or dead, the habitual death of the fœtus in utero, and the changes that ensue after death in the fœtus itself.

The effect of the death of a fœtus upon its mother may be said to be practically nil. It is only when the dead body undergoes putrefactive changes, or when, the soft parts being absorbed, there is an attempt to get rid of the fœtal bones by ulcerative processes into the bladder, vagina, or rectum, or externally through the abdominal walls, that the mother's health and safety are endangered. Thus after ectopic gestation the dead fœtus may remain for an indefinite period within the mother's abdomen, without giving rise to greater inconvenience than would be caused by the enlargement of the abdomen; but should the germs of putrefaction gain access to the dead body, as they may by reason of the contiguity of the intestines (Litzmann), then a general suppurative peritonitis may be developed and rapidly prove fatal. So, too, in the retention of blighted ova[2] or in cases of missed labor[3] there is usually no evidence of serious harm to the mother until the putrefaction of the dead body begins, when there may be shortly manifested all the symptoms of septicæmia, unless the uterine cavity be speedily cleared of its contents and well disinfected.

It is by no means an easy matter to determine whether or not the

[1] *Elém. Physiol.*, vol iii. p. 314, quoted in Tarnier et Budin, *op. cit.*, p. 570.

[2] See Gehrung: *Weekly Med. Review*, Chicago, 1885, p. 131; *Westminster Hospital Reports*, 1885, i. 119; *Tokio Med. Journ.*, 1886, No. 439.

[3] Lusk: *Sci. and Art of Midwifery*, 1886, p. 304.

fœtus has ceased to live. If its death should have occurred during the early part of pregnancy, the uterus will usually cease developing; the breasts will soon become flabby, although "it is not rare for milk to appear after the death of the fœtus" (Tarnier); the woman may complain of subjective symptoms, as a feeling of weight and discomfort, in the hypogastric region (Lusk); but the doubt will usually soon be solved by the expulsion of the ovum. "It is not rare for the lacteal secretion to be established three or four days after the death of the fœtus, with all the phenomena characteristic of that function after delivery" (Tarnier). Should the fœtus die in the later months of pregnancy, the movements, theretofore perhaps active, will be felt no more by the mother, and the fœtal heart-sounds will no longer be heard. Neither of these signs, however, is entirely reliable, for the woman's statement will not always be perfectly credible, and it is impossible occasionally to hear the fœtal heart-sounds, although the child is alive and well. Negri[1] on one occasion was able to make the diagnosis of fœtal death during pregnancy by abdominal palpation, the fœtus presenting a rather confused outline and giving rise upon pressure of the mother's abdomen over the region of the fœtal head to an indistinct crepitus. His diagnosis was confirmed, as the woman shortly afterward gave birth to a macerated child. During labor a doubt will often arise as to whether the fœtus is dead or alive, and upon the decision arrived at will often depend the performance of embryotomy or of a more conservative operation. Under these circumstances it has been suggested by Cohnstein[2] and Fehling[3] that if the temperature of the uterus be found no higher than that of the vagina, the child may safely be pronounced dead; for the living fœtus, having a higher temperature than its mother, will impart some additional heat to the maternal structures about it. Priestley[4] more practically suggests that the hand be introduced into the uterus in order to feel in the præcordial region for the impulses of the fœtal heart. All these signs, however, will often fail, and the true condition of the fœtus remain in doubt until after delivery.

After death the fœtal tissues will in time saponify (adipocere), partially calcify, mummify, or else be totally or partially absorbed. The phenomena seen shortly after death consist in maceration and putrefaction. Before the second month the product of conception can be entirely absorbed. After that time the changes that take place depend to some extent upon the position of the fœtus. Within the uterus the dead fœtus is first macerated, becoming bloated in appearance, with a grayish-colored skin deprived of its epidermis in spots of greater or less extent, the head enlarged, the cranial bones floating loose under the scalp, and

[1] *Annali di Ostetricia*, May–June, 1885, p. 223.
[2] *Arch. f. Gyn.*, Bd. iv. H. 3.
[3] *Ibid.*, Bd. vii. S. 143.
[4] *Lancet*, Jan. 23, 1887.

the tissues so soft and friable that very slight force is sufficient to detach the limbs from the body. Should air be admitted to the fœtus in this condition by rupture of the membranes, decomposition would rapidly ensue. The other changes that affect the tissues after death in utero are a kind of saponification, and possibly mummification, in which latter state they will remain for an indefinite period without change. It is in abdominal pregnancies that the dead fœtus becomes converted into a so-called lithopædion, which consists, not in a petrifaction of the whole mass, but (1) in a calcification of the membranes after absorption of the liquor amnii; (2) in a calcification of the membranes and those points on the fœtus where the membranes adhere to the fœtal surface; or (3) in a deposition of lime in the vernix caseosa after the membranes have been ruptured and the fœtus has escaped into the abdominal cavity.[1] The fœtus in the abdominal cavity may undergo all the other changes that have been described, including putrefaction, and in addition, after all the soft parts have been absorbed, the bony skeleton may be discharged piecemeal, along with pus, through openings into the bladder, rectum, uterus, and vagina, or externally through the abdominal walls—a conservative action on the part of Nature to get rid of a foreign substance; but as a result of the prolonged suppuration the woman may succumb to exhaustion or septicæmia.

The Habitual Death of the Fœtus.—There are women who conceive, perhaps frequently, but who in two or more successive pregnancies, usually at the same period in each, give birth to dead children. It is important in these cases to inquire into the cause of this repeated death of the fœtus, for upon it depends the treatment that may be adopted to secure the birth of a living child. Unfortunately, however, such an investigation is hampered by the ignorance that as yet surrounds fœtal pathology, and although a considerable advance has been made since the time when every fœtal death was ascribed to syphilis or to a habit of aborting that might be acquired by the mother, yet the future must have much to teach us in regard to the morbid conditions that determine the death of the fœtus.

Although by no means the only cause of the habitual death of the fœtus in utero, syphilis is by far the most frequent one. According to Ruge's[2] estimate, 83 per cent. of the premature and stillbirths are to be explained by the existence of syphilis in either parent. But there are many cases in which syphilis can with certainty be excluded, and in which the death must be ascribed to one of the other conditions that modern investigation has shown to be occasionally responsible for a repeated interruption of the course of pregnancy.

Certain Conditions of the Uterus which Interfere with the Development of the Fœtus.—There are no reliable statistics in regard to the relative

[1] Küchenmeister: *Arch. f. Gyn.*, Bd. xvii. p. 153. [2] *Zeitschr. f. Geburtsh.*, Bd. i.

frequency of the causes, other than syphilis, of habitual death of the fœtus, but I should be inclined to place first chronic endometritis, and next perhaps chronic metritis—two affections which are of very common occurrence in child-bearing women, and of their unfavorable influence upon the progress of pregnancy there can be no doubt. Schroeder,[1] among others, speaks of the frequency with which a chronic endometritis can bring about an interruption of pregnancy, either by effusions of blood into the hyperæmic mucous membrane, and the consequent excitation of muscular action in the uterus, or by such an active growth of the decidua that the nutritive blood-supply is so diverted from the fœtus to the uterine mucous membrane that the former perishes.

Abarbanell[2] first called attention to chronic metritis as a cause of habitual abortion—an effect really to be expected from the excessive development of fibrous tissue in the body of the uterus, which by the loss of elasticity that it entails would interfere with a sufficient dilatation of the uterine cavity. Such, no doubt, is the explanation of that case of Baudelocque's[3] in which, after a Cæsarean section, a woman gave birth to four successive children at the seventh month of pregnancy.

Alterations in the Maternal Blood that are Fatal to the Fœtus—Scanzoni[4] has pointed out that a high grade of *anæmia* in a pregnant woman might be fatal to the fœtus; and his statement has been amply verified. The anæmia may be due to an exaggeration of that hydræmia which is characteristic of pregnancy, or to the development of pernicious anæmia,[5] to sudden loss of blood, or to lack of proper or sufficient food. To this last cause may be attributed the large number of abortions and stillbirths that occurred during the siege of Leyden (Hoffmann), or in Germany during the year 1826, when the crops failed (Naegele), and during the siege of Paris (Priestley).

The existence of *plethora* in the mother, on the other hand, has not such an unfavorable influence upon the fœtus, for the very existence of pregnancy usually corrects the evil. It is possible, however, that this condition might prove a predisposing cause to effusions of blood into the membranes or placenta, especially at a time corresponding to a menstrual period, when all the generative organs are disposed to congestion.

Chronic Diseases of the Mother in their Influence upon the Fœtus.—Women affected with tuberculosis,[6] cancer, or chronic malarial poisoning[7] may give birth to a succession of dead children—a result, no

[1] *Geburtshülfe*, 8th ed., Bonn, 1884, p. 405.
[2] *Monatschr. f. Geburtsh.*, xix. S. 106.
[3] Leopold: *Arch. f. Gyn.*, Bd. viii. p. 253.
[4] *Geburtshülfe*, Bd. ii. S. 3 u. 70.
[5] Gusserow: *Arch. f. Gyn.*, Bd. ii. S. 218.
[6] Tarnier et Budin, *op. cit.*, p. 89.
[7] Bompiani: *Annal. di Ostet.*, vii. 42, 46; Discussion of Dr. Schrady's paper, *Med. News*, 1885, i. 358; Negri: *Annal. di Ostet.*, viii. p. 277.

doubt, of the combined action of the disease itself and the anæmia that accompanies it. Icterus gravidarum also, whether simple, epidemic, or pernicious (see this volume, p. 284), might be a cause of repeated fœtal death, although the course of the last two is usually too rapid to allow of repeated impregnation.

Nephritis.—Fehling[1] has quite recently called attention to the influence of maternal nephritis as a cause of repeated stillbirths. The death of the fœtus is often the result of the morbid condition of the blood-vessels in the maternal portion of the placenta, corresponding to the condition found in the lungs, brain, and other organs in chronic nephritis. This leads to apoplexies and to the formation of large infarcts in the intercotyledonic spaces, which so compress the neighboring placental villi that they cannot perform their physiological functions. The effusion of blood, moreover, can have a more immediately fatal result for the fœtus by causing a premature detachment of the placenta.[2]

Maternal nephritis may be fatal to the fœtus in another way, for Charpentier and Butte[3] have shown that an excess of urea in the maternal blood may prove fatal to the fœtus by the direct poisonous influence of this substance. Disturbances in the maternal blood-pressure (Runge), and insufficient oxygenation of the maternal blood, may also occasionally be responsible for the fœtal death.

Diabetes.—This disease seems to have a most disastrous influence upon the fœtus. Matthews Duncan[4] collected the records of 19 pregnancies occurring in 17 women, in 7 of which the fœtus died in the latter part of pregnancy. In 2 cases the children were feeble at birth, and 1 child was diabetic.

Chronic Poisoning.—There are certain chemical substances which, taken into the system gradually and in small quantities, but constantly, have a most deleterious influence on the health of the fœtus. Constantin Paul[5] was the first to point out the evil influence of saturnism upon pregnancy. Of 123 conceptions observed by him, 64 ended in abortion, 4 in premature labor, and there were 5 stillbirths; only 10 children passed the age of three years. These observations have been since confirmed by Roque[6] and Rennert.[7]

It has also been asserted that female workers in tobacco are peculiarly liable to abortion or to giving birth to dead infants (Jacquemart, Kostial); but there is as yet some difference of opinion on the subject. Prof. Hunter Maguire of Richmond, Virginia, very kindly inquired

[1] *Arch. f. Gyn.*, Bd. xxvii. p. 300.
[2] Winter: *Zeitschr. f. Geburtsh.*, Bd. xi. S. 398.
[3] *Trans. Ninth International Medical Congress.*
[4] *Obstet. Trans. London*, vol. xxiv. p. 256.
[5] Tarnier et Budin, *op. cit.*, p. 31.
[6] *Thèse de Paris*, 1873.
[7] *Arch. f. Gyn.*, Bd. xviii. p. 109.

for me of some of the largest tobacco-manufacturers in that city in regard to the effect of tobacco on the pregnant women in their employ. It was positively asserted that there was not the slightest evidence to sustain the belief that, in this country at least, tobacco-workers were liable to give birth to dead, premature, or feeble children.

Causes of Death residing in the Fœtus itself.—It has been already stated that syphilitic disease of the fœtus or ovum will be by far the most frequent cause of habitual death; but there are other causes residing in the fœtus itself which remain after the rigid exclusion of syphilis. It is well known that deformities may be hereditary in certain families, carried through every member of several generations.[1] So a woman might give birth to a number of children each presenting the same deformity, which might be grave enough to destroy life.[2] There is also a curious affection which Leopold[3] discovered to be the cause of death in several dead fœtuses born successively of one woman. This consisted in a thickening of the fibrous and muscular coat of the umbilical vein to such an extent that its calibre was considerably diminished. This thickening of the coats of the umbilical vein is one of the manifestations of syphilis, it is true, but in Leopold's case there was not the slightest evidence of this disease having existed in either parent.

The Causes of Fœtal Death referable to the Father.—In certain cases, where it is impossible to attribute the habitual death of the fœtus to the slightest ill-health of the mother, and where the product of conception itself presents no definite evidence of disease, except, perhaps, an appearance of having been weakly developed, the explanation of the unfortunate termination of repeated pregnancies must be sought in the condition of the father. He may be too old or too young to furnish a fecundating germ of sufficient vigor to enable the fœtus to reach maturity, or he may be the subject of some chronic debilitating disease, as nephritis,[4] diabetes,[4] phthisis,[5] cancer,[6] or chronic lead-poisoning,[7] which may not affect the fecundating power of the spermatic particle, but will render it incapable of performing its part in building up a healthy embryo. Thus, Priestley tells of a healthy young woman whose husband had albuminuria, giving birth first to a sickly infant, and afterward aborting in three successive pregnancies, or until her husband

[1] *Br. Med. Journ.*, Jan. 22, 29, 1887; *Am. Journ. of Obstet.*, 1886, p. 1108.

[2] A lioness in the Philadelphia Zoological Garden has given birth, on three separate occasions, to cubs that were deformed about the jaws and palate, and lived only a few moments after birth.

[3] *Arch. f. Gynäk.*, Bd. x. p. 191.

[4] Priestley: "Lumleian Lectures on the Pathology of Intra-uterine Death," rep. from *Brit. Med. Journ.*, 1887, p. 8.

[5] D'Outrepont: *Neue Zeitschr. f. Geburt.*, 1838, Bd. vi. p. 34.

[6] Jacquemier: *Dict. Encyc. des Sc. méd.*, art. "Avortement," vol. vii. p. 537.

[7] Constantin Paul: *loc. cit.*

succumbed to uræmia. D'Outrepont also has related the following case: A woman married to a phthisical man became pregnant five times, in each instance giving birth to a dead child at the eighth month. Remarried to a healthy husband, she gave birth to four healthy infants in succession. Paul observed 39 pregnancies in seven women whose husbands were afflicted with saturnism, but of this number there were 11 abortions and 1 stillborn child, while of the 27 children born alive only 9 survived early infancy.

The Habit of Giving Birth to Stillborn Children.—If one can exclude all the causes in the mother that have been enumerated as responsible for the death of the fœtus, if there is no sign of abnormality or disease in the fœtus or ovum, or if there is nothing in the condition of the father that might account for the repeated stillbirths, then their occurrence may be attributed to a habit of the mother of giving birth to dead children. Such cases are extremely rare, as may be imagined, but are by no means unknown. Two examples may be cited: A woman[1] subjected to a severe fright in the last month of pregnancy afterward gave birth to a dead child. In twelve successive pregnancies she gave birth to dead children at the seventh month. The mother[2] of Hohl gave birth alternately to living and dead children. The first child was living and healthy, the second dead, and so on till the tenth pregnancy, when so certain was the lady that her child would be born dead that she provided nothing for it. It was born alive, however, and was no other than Hohl himself.

To Determine the Cause of Repeated Stillbirths.—The suspicion of syphilis in the parents will usually be the first to arise in the mind of a practitioner who meets with a case of habitual death of the fœtus; but, aside from the possible injustice of such a suspicion, it may suggest a false system of therapeusis. It is therefore most important to discover the true cause of the inability of the woman to bear a living child, for the treatment that may be adopted to prevent a repetition of the stillbirths must differ most radically with each of the many causes that have been enumerated above. Syphilis, as by far the most frequent cause of habitual death of the fœtus, must be first excluded before another cause is sought. But this is by no means always an easy matter. If there is a distinct history or evidence of syphilis in either parent, or if the child is born with an extensive pemphigoid eruption, especially on the soles of the feet or palms of the hand, the diagnosis is easily made. It more frequently happens that the history of the parents is obscure, and that the fœtus is expelled already macerated or with no distinctive marks of disease upon its body. In such a case a careful examination of the fœtal body will usually reveal unmistakable evidence of the existence of syphilis. The most valu-

[1] Hayes: *London Lancet*, 1874, vol. ii. [2] Tarnier et Budin, *op. cit.*, p. 365.

able signs of fœtal syphilis are three in number: (1) An osteo-chondritis, which can best be seen between the head and shaft of the femur, but may be detected between the epiphyses and diaphyses of all the long bones, giving rise to a ragged yellowish line of premature ossification undergoing fatty degeneration that can readily be made out with the naked eye; there is along with this very often a detachment of the epiphysis from the diaphysis. Wegner[1] first called attention to this sign of fœtal syphilis, and in Germany it is known by his name. Much importance was attached to it by the late Prof. Schroeder,[2] and I have myself found it of value in the Philadelphia Hospital. (2) According to the careful experiments of Ruge,[3] the liver of a newborn infant should form one-thirtieth part of the total body-weight. In syphilitic infants, however, this proportion is always exceeded, the liver reaching in some instances one-twelfth or more of the total body-weight. (3) According to the same authority, the spleen should form one-three-hundredth part of the total body-weight. This organ is also, however, much enlarged in syphilis, weighing, according to Lomer, much more than its due proportion to the weight of the fœtus. These three signs, then, taken together, make the diagnosis of syphilis reasonably sure. If in addition there are found inflammation of the serous membranes and gummatous formations in the placenta, the diagnosis becomes all the more certain.[4]

If, however, it is possible to exclude syphilis as a cause of the recurring death of the fœtus, another cause must be sought. It will be necessary to learn the condition of the uterus, whether there be inflammation of its lining membrane or body, or whether the whole organ is displaced or its cervix lacerated. Should the appearance of the patient suggest either anæmia or plethora, the blood must be examined. The lungs should be examined for phthisis, and the urine for sugar or for albumen and casts. The history of the patient may point to the existence of malaria or of chronic lead- or tobacco-poisoning. Physical signs may denote a cancer, or there may be unmistakable jaundice. The fœtus itself must be examined for some hereditary defect, and the cord for stenosis of the umbilical vein. Finally, the condition of the father must be inquired into—whether he be too young or old or the subject of some debilitating disease. If all these signs fail, then the diagnosis must rest upon a habit or an hereditary predisposition of the mother.

The Preventive Treatment of Habitual Death of the Fœtus.—The measures to be adopted to prevent the repetition of a stillbirth must depend upon the cause that has given rise to the death of the fœtus in the past. In the case of syphilis of the parents an appropriate anti-

[1] *Virchow's Archiv*, Bd. l. p. 305.
[2] See Lomer: *Zeitschr. f. Geburt.*, Bd. x.
[3] *Zeitschr. f. Geburt.*, Bd. i.
[4] Lomer: *loc. cit.*

syphilitic treatment should be adopted and continued for many months; and it would be advisable to interdict, or at least very much restrict, sexual intercourse during the duration of the treatment, in order to spare the woman the discomforts or dangers that might attend another pregnancy ending in abortion if impregnation should occur before the specific virus was thoroughly eliminated from either parent. So frequently is an antisyphilitic treatment successful in these cases that certain writers have recommended the administration of potassium iodide or mercury to every woman who was in the habit of giving birth to dead children. Such a practice, however, would be irrational, and in some cases perhaps harmful. If syphilis can be excluded, or if a woman in any case first comes under observation after impregnation has occurred, a treatment first suggested by Simpson[1] with a view of increasing the oxygenating power of the maternal blood might be adopted. This consists in administering to the pregnant woman large doses of chlorate of potassium, which, by the large proportion of oxygen it contains, is supposed to supercharge the maternal blood with the gas, and thus compensate for the diminished area of effective placenta in cases of fibrous or other degeneration of that organ. Whatever the explanation, this treatment certainly met with success in the hands of its originator, and has since been recommended, among others, by Bruce, Inglis, Carl Braun, Fordyce Barker, and Penrose. If there should be a chronic endometritis, its treatment by the curette may be followed by conception and a normal pregnancy.[2] A correction of a displacement of the uterus or a repair of a lacerated cervix may be followed by the same happy result. In anæmic women a tonic treatment, especially with the salts of iron, will often be followed by the birth of a vigorous infant, although the woman may have previously had a succession of premature stillbirths. If along with the iron the patient obtains change of air and scene and a life in the open air, the effect will be all the more decided. These combined advantages are to be best obtained at some of the well-known chalybeate springs in this country and in Europe, such as those in Western Pennsylvania or Virginia, or those of Pyrmont, Schandau, Schwalbach, or Neuhaus. Plethoric patients, on the other hand, would be benefited by increased exercise, by frequent depletion, and by a restricted diet, or a course of the waters at Saratoga, Kissingen, or Carlsbad might be beneficial. Phthisis, cancer, diabetes, or nephritis in the mother renders the prognosis for the fœtus grave; especially in the last does treatment seem to be of no avail (Leopold). In chronic malarial-, lead-, or tobacco-

[1] Sir J. Y. Simpson: *Obstet. Memoirs*, ed. by Priestley and Storer, Edinb., 1865, vol. i. p. 460.

[2] Schroeder: *Geburtshülfe*, 8th ed., p. 405.

poisoning the elimination of the poison should enable the woman to bear a living, healthy child.

A chronic, incurable disease in the father may so deteriorate the quality of the spermatic particles that, while conception may occur, the development of the embryo will be impossible. Should his condition, however, admit of improvement, the male fertilizing element may gain sufficiently in vigor to perform its part in the growth of the fœtus.

There are women who carry a living child up to a certain period of pregnancy, but if allowed to go to term give birth repeatedly to dead infants. Thus, Tarnier[1] tells of a woman, apparently in good health, who gave birth to thirteen dead children successively, although it was demonstrated that the fœtus was in each instance alive until the last month of pregnancy. The same authority cites another instance of a woman who in seven successive pregnancies experienced the active movements of her child until within fifteen days of the normal time of delivery, and yet always gave birth to a dead infant. In such cases as these it is evident that the birth of a living child could be secured by inducing premature labor at a time before the period of pregnancy at which the accustomed death of the fœtus occurred. It will often be peculiarly gratifying to the physician to secure to a woman the birth of a living child after several abortions or stillbirths have occurred, from its possibly important bearing upon domestic happiness or the inheritance of property. With a careful inquiry into the cause of the previous failures to bear living children, and a judicious adaptation of the treatment to the cause, the efforts to prevent a recurrence of the habitual death of the fœtus will usually be crowned with success.

Abnormalities, Deformities, and Monstrosities of the Fœtus.

An exhaustive study of the innumerable deviations from a normal development that may be found in the fœtus has become a work of such magnitude that it must be left to the teratologist, and can no longer be included in a practical work on Obstetrics. It is a subject, however, that must have some interest for every obstetrician, and therefore for convenient reference a classified table of the anomalies and monstrosities most frequently met with is appended, along with a very brief description of the most interesting deformities that may at any time occur in the course of an active practice. The classification of Geoffroy St.-Hilaire has been adopted, as on the whole the best, following in this the example of Tarnier. This classification is open to the

[1] *Loc. cit.*, p. 365.

objection, however, common to all attempts at separating the anomalies and deformities of the fœtus from the monstrosities—that it is impossible to draw a sharp dividing-line between the two.

Every fœtus that presents any deviation from the normal may be classed as

(1) Hemiteratic;[1]
(2) Heterotaxic;[2]
(3) Hermaphroditic;[3] or,
(4) Monstrous.

The HÆMITERATA may be classified as follows:[4]

Anomalies of Growth.—Dwarfed or gigantic children; retarded or precocious development.

Anomalies of Volume.—Smallness of limbs; defective development of muscles, of the breasts, of the thymus gland, of the vagina, etc.; excessive size of the head, of the breasts; lactiferous breasts in the male, etc.

Anomalies of Form.—Deformities of the head, anomalous forms of stomach, uterus, vagina, pelvis, etc.

Anomalies of Color.—Complete or partial albinism or melanism.

Anomalies of Structure.—Cartilaginous condition of bones, abnormal ossification, etc.

Anomalies by Displacement of the Splanchnic Organs.—Encephalocele, meningocele, displacement of the thoracic and abdominal viscera, as in eventration, extrophy of bladder, tardy or precocious descent of the testicles, etc. etc.

Anomalies by Displacement of Non-splanchnic Organs.—Club-foot, curvature of spine, displacement of vessels, etc.

Anomalies by Change of Connection.—Abnormal articulations of bones, abnormal implantation of teeth, abnormal attachments of muscles and ligaments, abnormal branches of arteries and nerves.

Anomalous Openings.—Abnormal openings of the vessels into the heart, of the thoracic duct, of the vagina, the intestines, the urethra, the ureters; abnormal existence of a cloaca.

Anomalous Imperforations.—Imperforation of the rectum, vulva, urethra, œsophagus, mouth, pupils of iris, etc. etc.

Anomalous Union of Organs.—Union of the kidneys, testicles, fingers, toes, teeth, ribs, etc.; adhesion of the tongue to palate.

Anomalies by Disjunction.—Persistence of the urachus (patulous), of the ductus arteriosus, fissures of various organs, hare-lip, epispadias and hypospadias, sternal fissure, and spina bifida.

Anomalies by Numerical Diminution.—Absence of muscles, of long

[1] From ἥμισυς, the half; and τέρας, monster. [2] ἕτερος, other; τάξις, order.

[3] Ἑρμῆς, Mercury, and Ἀφροδίτη, Venus.

[4] Tarnier et Budin, *op. cit.*, p. 390.

bones, vertebræ, ribs, teeth, digits; of a lung, a kidney; of the uterus, the vagina, or the bladder.

Anomalies by Numerical Augmentation.—Supernumerary muscles, tendons, ribs, teeth, fingers, and breasts; uterus didelphis.

The second division of fœtal deformities consists in the so-called HETEROTAXIS, or "the simple change in the situation of the viscera." This may involve only the internal organs (splanchnic inversion) or the external also (general inversion). Thus the cardiac end of the stomach may lie to the right side; the heart may be transposed to the right side; the main development of the liver may be upon the left side; the large abdominal vessels may have their positions transposed. This may be accounted for by the fact that the development of the organs that become ultimately unilateral occurs primarily in a symmetrical manner in the median line; one or the other side atrophies, and the other goes on to its normal development. Should this normal arrangement be interfered with, a growth in an unusual situation may be the result.

HERMAPHRODITISM.—There is a time in fœtal life when the elements of both sexes seem to be present in equal force. The duct of Müller and the duct of Wolff lie side by side; the sexual eminence contains the germs of both an ovary and a testicle; and the elevation which subsequently forms either the clitoris or the penis is prepared to develop indifferently into either organ. But as the determination of sex becomes evident, in the case of a female the duct of Müller develops, while the Wolffian duct atrophies; the female elements of the primordial tissue constituting the so-called sexual eminence develop into an ovary, and the external elevation becomes converted into a clitoris, while the skin around it arranges itself into the labia majora and minora, leaving a cleft in the median line to communicate with the vagina, which, with the uterus and tubes, has been formed out of the ducts of Müller.[1] Such, briefly, is the normal development of the female sexual organs.

But this normal growth is sometimes replaced by most curious deviations from the natural development. Both the male and female elements in the fœtus may grow with equal vigor, and the bisexual development may persist till adult life, so that one individual may possess ovaries, tubes, a uterus, and a vagina, along with a penis, scrotum, and testicles. Such a person is a true hermaphrodite in the strictest sense of the modern interpretation of the term, but true hermaphroditism may be said to exist even when there is not such a complete development of all the male and female organs in a single individual. Thus there may be an ovary on one side and a testicle on the other;[2] there

[1] Fowler: *Am. Journ. Obstet.*, April, 1887, p. 423.

[2] Three such cases are reported by Berthold, Barkow, and Meyer: Tarnier et Budin, *loc cit.*, p. 415.

may be testicles and ejaculatory ducts with the external genital organs of a woman, or two testicles with a clitoris, labia, vestibule, and vagina. These true hermaphrodites—that is, individuals possessing, in whole or in part, the sexual organs of both sexes—must be distinguished from those males affected with a marked hypospadias, associated perhaps with extrophy of the bladder. While a student in the Philadelphia Hospital I saw such a person who had been educated and clothed as a girl until his nineteenth year.

MONSTROSITIES.—A monstrosity is a creature exhibiting a congenital deformity of such gravity as to be incompatible with life, or which impresses the beholder with such wonder, disgust, or horror that the ancients regarded it as a sign (*monstrum*) of the displeasure of the gods. The etiology of these monstrous productions is often obscure, although they are occasionally explained by the existence of syphilis of the ovum, inflammation of the fœtal serous membranes or of the amnion, maternal impressions, or the unfavorable influence of one fœtus upon the other in multiple pregnancies. They may be divided into two great classes—the single and composite monsters. Single monsters may be further classified as follows:

A. *Autositic Monsters.*—These are so called because they obtain their own nourishment; that is, they are not dependent upon the circulation of another fœtus, as are the Acardias. They are divided into—

(1) *Ectromelic Monsters.*—In these there is an aborted development of the limbs (*ἐκτρώω*, to abort; *μέλος*, a limb).

(2) *Symelic Monsters.*—This deformity consists in a union, more or less complete (sirens), of two limbs of a single fœtus.

FIG. 182.

A Symelic Monster (Tarnier, Maternité).

(3) *Celosomatic Monsters* (*κήλη*, hernia; *σῶμα*, body).—In this variety there is a more or less complete eventration, associated with other deformities, of the limbs and genito-urinary organs.

(4) *Exencephalic Monsters.*—Here a badly-formed brain is situated more or less without the cranium, which is itself malformed.

(5) *Pseudencephalic Monsters.*—In this class the vault of the cranium is wanting, but there remains a vestige of the brain in the shape of a small tumor made up of blood-vessels and nervous tissue.

Fig. 183.

Exencephalic Monster.

Fig. 184.

A Cyclops (Tarnier, Maternité).

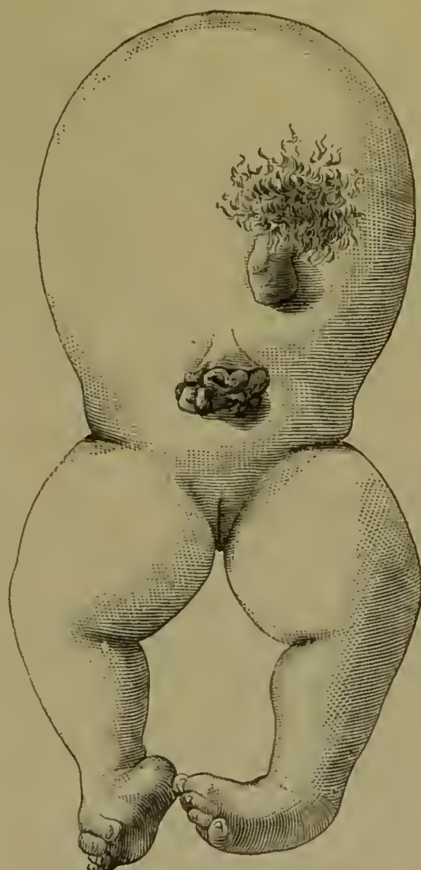
(6) *Anencephalic Monsters.*—This monstrosity is of not infrequent occurrence. Here, too, the vault of the cranium is wanting, but there is no trace of a brain. The head is set close upon the shoulders, which are unusually broad and well developed, as indeed is the rest of the body, and the eyes are prominent and staring.

(7) *Cyclocephalic Monsters* (cyclops).—In these creatures the nose is wanting and the two eyes, usually imperfectly developed, converge toward the median line, and are, as a rule, intimately united with one another.

(8) *Otocephalic Monsters.*—This monstrosity is distinguished by the convergence of the ears, and occasionally their union in the median line. There is an accompanying defective development of the lower portion of the skull.

B. *Omphalositic Monsters.*—This form of monster leads a parasitic existence in utero, receiving its nourishment from another fœtus, which is usually strongly developed. The explanation of this form of monstrosity is to be found in the fact that when two embryos are developing within a single chorion, one often exceeds

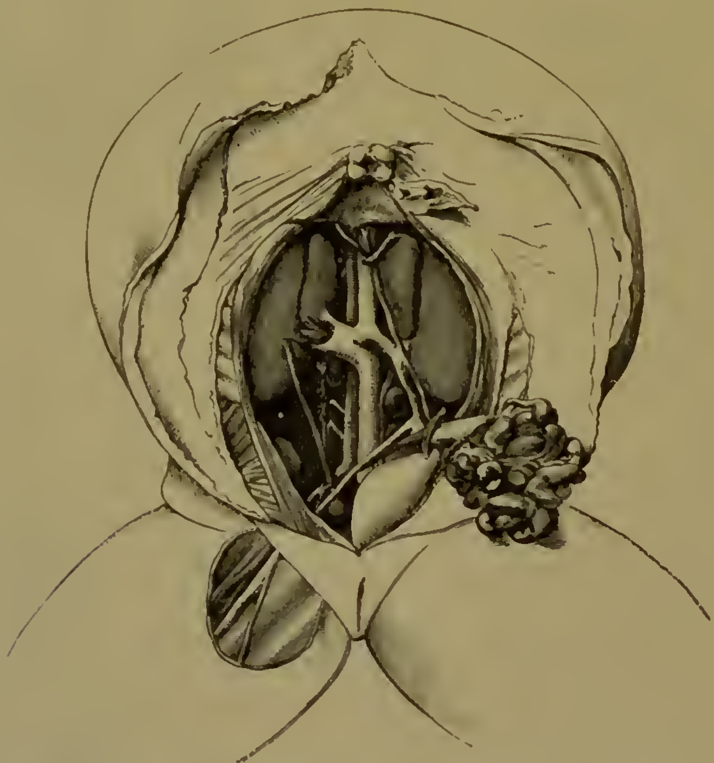
Fig. 185.



An Acephalic Monster (Veendam).

the other in strength, and the circulation of the stronger fœtus, meeting that of the weaker one in the placenta, reverses it, and thus renders the latter's heart useless, which as a consequence atrophies and disappears (acardia). And the fœtus itself grows as a more or less shapeless mass, sometimes without a head (acephalic), rarely without a body

Fig. 186.



An Acephalic Monster, showing on dissection the acardiac condition (Veendam).

(asomatic), and occasionally presenting none of the characteristics that would distinguish it as the offspring of a human being (fœtus amorphus, anideus).

Composite Monstrosities.—Composite monsters are formed by the union, more or less complete, of two or more fœtuses. Various theories have been advanced to account for this union. It has been ascribed to some condition of the ovule or of the spermatic particle before conception; it has been said that each embryo began its development separately, and that they afterward united, or that the embryo was originally single, but in a certain period of its growth took on a dual formation. The most reasonable belief would seem to be that the nucleus of the ovule has the power of dividing itself by fission, and that during the process of division, before the two were completely separated, impregnation occurred.

FIG. 187.

The Siamese Twins (xithopagus). (From a plaster cast in the College of Physicians.)

Composite monstrosities may be classified as follows:

A. *Double Autositic Monsters*, which are subdivided into—

(1) *Eusomphalic and Monomphalic.*—These monsters have respectively each a well-formed umbilicus or a single umbilicus. In this class are included the monsters united at the sternum (sternopagus), the pelvis (ischiopagus), the head (cephalopagus), the xiphoid cartilage (xithopagus), etc.

FIG. 188.

A Synsomatic Monster (Ahlfeld).

(2) *Syncephalic and Monocephalic Monsters.*—In the first variety there is not only a junction, but an intimate fusion, of the two heads, the bodies remaining separate; and in the monocephalic monster the junction and fusion are even more complete, so that it would be difficult to distinguish the composite nature of the deformity, were it not for the separate bodies.

(3) *Synsomatic and Monosomatic Monsters.*—This deformity consists in a fusion more or less complete of the two trunks, the heads remaining separate and distinct, the difference

between the synsomatic and the monosomatic variety being one only of degree. The latter is distinguished by a fusion so complete that it is difficult or impossible to demonstrate the line of demarkation between the two bodies.

B. *Double Parasitic Monsters* may be further subdivided into—

(1) *Heterotypic and Heteralien.*—These monsters are distinguished (1) by the insertion of the parasitic fœtus at some point in the anterior abdominal wall of the autositic individual, sharing its umbilical cord; and (2) by the insertion of the parasite at a distance from the umbilical cord of its host. These varieties are very rare.

(2) *Polygnathic Monsters.*—This deformity consists in the attachment of a parasitic fœtus, more or less imperfectly formed, to the upper jaw (epignathus) or to the lower jaw (hypognathus) of the autositic fœtus.

(3) *Polymelic Monsters.*—In this variety of monsters one or more limbs of a parasitic fœtus project from various portions of its host.

(4) *Endocymatic Monsters.*—Under this name (*κῦμα*, the fœtus, and ἔνδον, within) is classed what are to-day more commonly called dermoid cysts, containing often not only organs directly derived from the epidermis, as tissues having the formation of eyes, breast, etc., but also bones, feet, etc. In this class, too, belong those interesting and rare cases of fœtus in fœtu.[1]

C. *Triple Monsters.*—These, as Tarnier says, "occur only as extremely rare exceptions in triple pregnancies, which are themselves rare."[2]

Abortion, Miscarriage, and Premature Labor.

The term "abortion" is usually applied to the expulsion of the ovum before the fourth month, at a time when the placenta is not yet differentiated from the rest of the chorion. Premature labor signifies, to the majority, the delivery of a fœtus that has become viable. For the expulsion of the ovum during the intervening time from the fourth to the seventh month of pregnancy a distinctive term is needed, as the process, in combining some of the features of both abortion and premature labor, presents a clinical picture different from either of them. To denote the interruption of pregnancy at this time the word "miscarriage" will here be used.

The Causes of Premature Expulsion of the Ovum.

Many of the conditions which interrupt the course of pregnancy have been referred to. The death of the fœtus; abnormalities and diseases

[1] Dumas: *Arch. f. Gyn.*, Bd. vii. p. 384.

[2] This table of monstrosities is taken, very much condensed, from Tarnier et Budin, vol. ii., *Traité de l'Art des Accouch.*, pp. 418–472. For fuller information the reader is referred to that excellent treatise on the pathology of pregnancy.

of the membranes, including the deciduæ; pathological conditions of the placenta and apoplexies of the ovum; traumatism and certain diseases of the mother,—have all been noticed. But the maternal diseases have been regarded chiefly as to their effect directly upon the embryo, fœtus, or ovum. There are, however, certain conditions of the mother which have as their primary effect the active contraction of the uterine muscle, which results secondarily in the premature expulsion of the ovum, although the latter may be normal in every respect.

Irritable Uterus.—From clinical observation one must feel inclined to ascribe to every uterus a special temperament, which, as the case may be, is irritable, equable, or apathetic. It is notorious that some pregnant women are liable to lose the product of conception from a trivial cause. A long walk, a dose of some mild purgative, the jolting of a carriage, a misstep, especially while descending a staircase, not to mention exercise on horseback or dancing, have been followed by the expulsion of the ovum. A case of this sort is known to the writer. A young primigravida was recommended by her physician to walk a mile every day in the open air. This advice was followed but once or twice, when premature labor came on, for which no other cause could be assigned than the very slight physical exertion that had been made. In such cases the greatest care must be exercised to guard the woman from anything which might stimulate uterine contractions, and at the time corresponding to the menstrual period the precautions must be doubled. If this disposition to abort is noticed in a woman who has borne a child at term, it would be well to examine the cervix, for an extensive laceration in that quarter will account for some cases of habitual abortion, and a repair of the injury will enable the uterus to retain an impregnated ovum. Very many other causes might be enumerated that would induce a pregnant uterus to expel its contents when the uterine muscle is prone to respond too readily to any stimulus. Congestion of the pelvic organs, common in prostitutes, who ply their trade regardless of their condition, may account for the abortions that occur so frequently in these women. The same condition, due perhaps to over-frequent marital relations, to working the treadle of a sewing-machine, or simply to the chronic constipation characteristic of civilized woman, may excite an irritable uterus to action. Reflex stimulation of the womb, as from irritation of the nipples while suckling a child, from some trifling operation like the extraction of a tooth, from the scratching of the vulva induced by pruritus, or from a diseased ovary, will be sufficient, in some cases, to set up active uterine contractions. The opposite picture, while not so familiar, is occasionally seen. Some women can make the most violent exertions, can receive the roughest treatment, without bringing their pregnant condition to an end. English writers tell of ladies who follow the hounds over the most difficult country in the early months of pregnancy without aborting. The case of a pregnant woman who was thrown upon the ground and whose abdomen was stamped upon, but who, nevertheless, went on to term, has been described. Sounds have been introduced into the pregnant uterus; intra-uterine injections have been given;[1] strong applications have been made to the endometrium; trocars have been plunged through the uterine wall;[2] pregnant women have been thrown violently from a carriage;[3] in one case a young girl, five months pregnant, cast herself from the Pont Neuf into the Seine;[3] in another fifteen leeches were applied to the cervix of a pregnant uterus;[3] Emmet's operation has been performed upon the cervix during the second month of pregnancy;[4] ovariotomy and other serious surgical operations have repeatedly been performed,—all without inducing abortion or premature labor.

Spasmodic Muscular Action in the Mother as a Cause of Premature Expulsion of the Ovum.

Pregnant women affected with chorea, eclampsia, uncontrollable vomiting or coughing, epileptic, hysterical, or cholæmic convulsions, or with tetany, are very liable to expel the product of conception prematurely.

Chorea.—Less than half of the women affected with chorea gravidarum will go on to term. Of 57 cases collected by Barnes, only 22 completed the full time of pregnancy. Bamberg's statistics of 64 cases show 33 arrived at term, and Spiegelberg of 69 cases saw only 29 delivered of mature infants.[5]

The reason for the premature termination of pregnancy in these cases is not quite clear. Perhaps the physical exhaustion due to almost incessant muscular action explains it. It may be that the muscular contraction disturbs the venous circulation, brings about a stasis in the uterine veins and a consequent excess of carbonic oxide gas, which may excite the uterine muscle to action (Brown-Séquard). In a case recently under my observation the uterine muscle toward the end of pregnancy seemed to partake in the choreic movements that convulsed the muscles of the extremities. Through the abdominal wall the uterus could be felt firmly contracting at intervals of not more than a minute. Every contraction was extremely painful, but during the four days that this con-

[1] Scanzoni: *Lehrb. der Geburts.*, Wien, 1867, p. 83.

[2] Many cases are reported of tapping a uterus distended by hydramnion in mistake for an ovarian cyst or ascites.

[3] Tarnier and Cazeaux, 8th ed., p. 567.

[4] Juillard: *Nouvelles Archives d'Obstét. et de Gynéc.*, 1886, p. 645.

[5] Hervé: *Thèse de Paris*, 1884.

dition of the uterus lasted the os showed no sign of dilatation. The suffering finally became so great that labor was induced by Krause's method.[1]

Eclampsia.—The eclampsia of pregnancy in the great majority of cases determines the premature expulsion of the ovum. Frequently, no doubt, the life of the fœtus is first destroyed; often, however, the immediate effect is seen in expulsive efforts of the uterus, due to the asphyxia of the organ, to the irritating effect of urea, carbonate ammonia, or ptomaïnes in the blood, or perhaps to the fact that the uterine muscle shares in the convulsive action of the whole muscular system.

Uncontrollable Vomiting and Coughing.—The constant violent action of the diaphragm in cases of uncontrollable vomiting and coughing during pregnancy often leads to the expulsion of the ovum. Of 51 cases of uncontrollable vomiting collected by Guéniot, 20 ended in abortion or premature labor.[2] A violent and persistent cough will also, in rare instances, by the constant succussion in the abdominal cavity, be the cause of prematurely expelling the ovum.

Epileptic, Hysterical, Cholæmic, and Tetanoid Convulsions.—According to Tarnier, attacks of epilepsy during pregnancy can be disastrous for the fœtus, either in killing it outright or in bringing about its premature expulsion. Tanner mentions a case of hysterical convulsions which was followed by the expulsion of a dead fœtus at the seventh month.[3] Cholæmic convulsions occur perhaps more frequently than is generally suspected,[4] and they always interrupt pregnancy, either by the death of the mother or the expulsion of the ovum. Meinert[5] has recently collected 11 cases of a tetanoid condition in pregnancy, in 6 of which there was true tetany. In 2 of the 11 cases dead children were born, one prematurely at the seventh month, the other at term. In one other case the child was expelled at the eighth month, and in another eleven days before term.

Conditions of the Maternal Blood which Stimulate the Pregnant Uterus to Expulsive Efforts.—The poisons of all the infectious diseases in the maternal blood are more or less liable to excite active contractions in the pregnant uterus. Whether this is due to some irritative action of the micro-organisms or to the development of leucomaïnes,[6] or to a diminution of the oxygenating power of the blood, as yet remains in doubt. The last condition, however, must be called upon to explain the abortions occurring so frequently during an attack of pneumonia, as well as in cases of chronic heart disease, in which the circulation is

[1] For a report of the case see *Trans. Philadelphia Obstet. Soc.*, Dec., 1887.

[2] See Tarnier et Budin: *op. cit.*, p. 59.

[3] *The Signs and Diseases of Pregnancy*, London, 1867, p. 304.

[4] Stumpf: *loc. cit.*

[5] *Arch. f. Gyn.*, Bd. xxxi. S. 444.

[6] A. M. Brown: *Treatise on Animal Alkaloids*, London, 1887.

much interfered with. It is possible also that powerful emotions alter the blood in some way that would account for the action of the uterus when women have been badly terrified. But it is more likely that the action is analogous to that of the rectal and vesical muscles in cases of nervous defecation and urination. Thus, Baudelocque used to tell in his lectures how, after the explosion of the powder-mill of Grenelle, he was called to see 62 women either aborting or threatened with an abortion.[1] In all maternal diseases accompanied by fever the thermic irritation of the uterine muscle might be held responsible for the expulsive efforts of the uterus; but there are in these cases other conditions offering a more probable explanation for the abortion. There is one acute infectious febrile affection not often referred to in works on Obstetrics, and which has not yet been noticed here—*miliary fever*, the *suette miliaire* of the French. This disease occasionally appears as an epidemic in certain parts of Italy, Switzerland, and France; it usually accompanies or follows an epidemic of one of the exanthemata, and is characterized by a very peculiar train of symptoms. There is an initial chill, followed by sweating and fever; on about the fourth day there appears an eruption, first upon the buttocks, spreading rapidly to the forearms and breast, consisting of little vesicles, sometimes white and transparent like sudamina, again surrounded by an areola of inflammation, or appearing first as red spots exactly like those of measles, in the centre of which finally develop the vesicles. Desquamation begins about the eighth day. There is such profuse sweating for the first six or seven days of the disease that the patients must change their linen three or four times in the twenty-four hours; there are intense headache and insomnia. There is a feeling of great oppression about the chest or thoracic constriction, usually coming on at night, when the sweats are most marked. In women there is often metrorrhagia, and in both sexes epistaxis. Dr. Parmentier[2] has recently described in a most interesting manner an epidemic of this disease. In all, there were 2068 persons attacked, of whom 131 died—a mortality of 6.3 per cent. But among the sufferers there were 9 pregnant women; of this number, 5 died, 2 recovered after aborting, and in only 2 cases had the disease no influence on the pregnancy. A mortality of 55½ per cent. in pregnant women, contrasted with the mortality of the disease in general, 6.3 per cent., shows that the condition of pregnancy increases the gravity of the prognosis in this as in most of the other acute febrile affections.

Uterine Contractions Excited by an Abnormal Situation or Position of the Uterus.—Retroflexion and prolapse of the gravid womb usually

[1] See Tarnier et Budin: *op. cit.*, p. 477.

[2] "Epidémie de Suette miliaire: ses Caractères dans le Canton de Lussac-les-Châteaux," *Revue de Médecine*, Sept., 1887.

lead to abortion, for the uterus is unable to properly expand in its unnatural position. This is true likewise of pregnancy in one horn of a deformed uterus.[1]

Perimetritis also, resulting in adhesions between the uterus and neighboring organs, or cellulitis, with plastic exudate in the broad ligaments, as well as diseases of a tube and ovary leading to adhesions, will, if pregnancy should occur, usually interrupt its course by interfering with the expansion of the gravid womb. Fibro-myomata of the uterine wall may act in the same manner, or else by the congestion of the organ to which they lead, or by acting as a mechanical irritant may stimulate the uterine muscle to contraction.

Over-distension of the Uterus as a Cause of Premature Expulsion of the Ovum.—If the uterus is unduly distended in hydramnion or in cases of multiple pregnancy,[2] especially where there are three or more fœtuses, the distension of the muscle often irritates it to expulsive efforts.

In twin pregnancies, should one fœtus die, the uterine muscle is occasionally stimulated to contraction, and the entire uterine contents are cast off, although the remaining fœtus may be healthy and normal. In cows epidemics of abortion have been observed, which have been attributed to a specific form of micro-organism, said by Franck and Roloff to resemble the leptothrix buccalis.[3] Brocard[4] has recently called attention again to this disease. It is improbable that the same disease can affect a woman, but in lying-in hospitals where antisepsis is not used—luckily, now the rare exception—an epidemic of abortion or premature labor might occur from septic infection during pregnancy.

Clinical History of Abortion and Miscarriage.

It will be noticed that premature labor is not referred to. Its course, management, complications, and after-treatment may be considered in the description of labor at term, from which it does not materially differ. The treatment of the premature infant may, however, be briefly referred to. The indications to be met in these cases are to supply artificial heat—for the production of heat by the life-processes in the infant is insufficient to sustain life—and to secure the entrance of small quantities of the infant's natural food, human milk, into the stomach at regular and frequent intervals, without the exposure necessary in frequent nursing by the mother and without the exertion of muscular force demanded to extract the milk from the breast, of which very often the infant is incapable. These requirements have only recently been adequately met by the

[1] Mundé: "Case of Pregnancy in One Horn of a Double Uterus, with Successive Miscarriages," *Am. Journ. Obstet.*, 1887, pp. 337, 346.

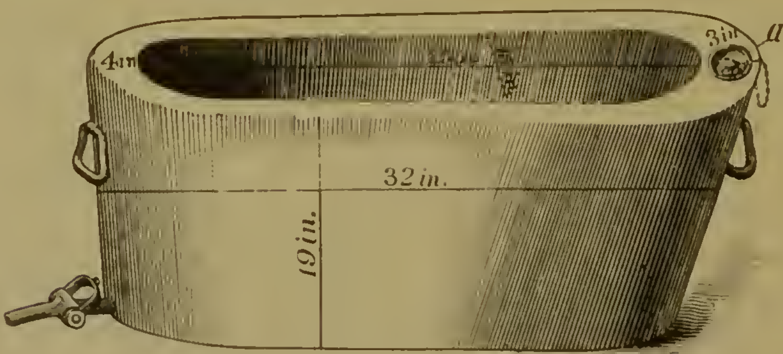
[2] See Doléris: *Nouvelles Arch. d'Obstét. et de Gynéc.*, 1886, p. 318.

[3] Schroeder: *Geburtshülfe*, 8te Aufl., 1884, p. 460.

[4] *Recherches sur l'Avortement épizootique des Vaches*, Broch., Paris, 1886.

use of incubators, such as those designed by Credé[1] and Tarnier,[2] and by a system of forced feeding proposed by Tarnier. Credé's incubator has been in use for more than twenty years in the Leipsic Maternity. In it have been placed 678 premature children, weighing, with few exceptions, less than 5¼ pounds each. Of this number, only 18 per cent. died. In the Maternité at Paris, since 1881, 151 premature children have been treated in Tarnier's incubator, and of this number 30 per cent. died, but the children all weighed less than 4 pounds. Tarnier's apparatus is complicated, and will probably not come into general use. Credé's appliance is readily made and easily handled. It is simply a bath-tub made of copper, with double walls, the space between them to

FIG. 189.



A Credé's Incubator in Use in the Maternity Hospital of Philadelphia.

contain hot water. According to Credé's directions, the space between the walls is to be filled every four hours with water at a temperature of 122° Fahr. This maintains a temperature within the tub varying from 107½ to 99½° Fahr. The tub is filled half full of cotton wool; the child, undressed, is placed upon the cotton wool with some absorbent cotton about its genitals which is to be renewed from time to time; the tub is then filled up with cotton, a space being left for the child's face, that it may breathe. Instead of the daily bath given to healthy infants, a premature child should be rubbed once a day with warm oil. In the Maternity Hospital of Philadelphia these children are fed by passing every hour a soft gum catheter into the stomach, through which is slowly injected, by means of an ordinary glass ear-syringe, a little more than a drachm of human milk at about the body-heat. The catheter and syringe are kept scrupulously clean, and the milk is pumped from the breast of the child's mother or some other healthy woman. This treatment, with us, gives excellent results.

THE CLINICAL HISTORY AND FREQUENCY OF ABORTION.—It is almost impossible to arrive at a correct estimate of the frequency of

[1] *Arch. f. Gyn.*, Bd. xxiv. S. 128.
[2] Auvard: "De la Couveuse pour Enfants," *Arch de Tocolog.*, 1883, p. 577.

abortion. So many women lose an impregnated ovum at an early period of its development, when they are not conscious even of being pregnant; so many others fail to seek medical advice for an abortion uncomplicated by hemorrhage or decomposition of retained secundines,—that almost all the estimates of the relative frequency of abortion and labor at term place the figure for the former too low. Hegar[1] says that one abortion will occur to every eight or ten labors at term, but the estimate of Guillemot and Devilliers,[2] of one abortion to every four or five pregnancies, is doubtless more correct—an opinion in which Tarnier coincides. Priestley[3] found that 400 women, among whom there had been 2325 pregnancies, gave a return of 542 abortions, or about one abortion to every four pregnancies. The main clinical phenomena of abortion are—(1) hemorrhage, (2) pain, and (3) the expulsion of more or less characteristic portions of an impregnated ovum. But these signs are rarely all manifested in a typical manner in every case. Pain may be absent, hemorrhage not excessive, and the whole ovum when cast off so small that it escapes unnoticed among the clots of blood that are discharged from the uterus. Such cases occur shortly after conception, and often pass for disordered menstruation, while the fact that pregnancy had begun is not suspected.

The duration of abortion varies in different cases to an extraordinary degree. The French speak of an "*avortement instantané*," and Cazeaux gives an example in a woman who fell upon her buttocks, and on rising found on her linen considerable blood and a six weeks' ovum. In some cases the expulsion of the ovum may occupy about the time consumed in a normal labor, but very frequently the process is a much slower one. Days, and even weeks, may be required for the uterus to get rid of its contents if left unaided to nature, and it is not rare for a fragment of the placenta or a portion of the uterine decidua to remain behind indefinitely, firmly attached to the uterine wall and often continuing to grow and develop, constituting within the uterus a true pathological new formation.[4] Of the two symptoms, pain and hemorrhage, the former is in early abortions usually the subordinate one. The hemorrhage is not often excessive, but can become alarming. The blood is expelled not in a steady flow, but from time to time as coagula. When the uterus finally throws off its contents, the appearance of the substance expelled differs as the ovum is cast off entire with its shaggy chorional coat, or surrounded by the decidua, which is often much thick-

[1] "Beiträge zur Pathologie des Eies," *Monatsch. f. Geburtsh.*, Supplem., Bd. xxxi. S. 34.

[2] Tarnier et Budin: *op. cit.*, p. 474.

[3] *Pathology of Intra-uterine Death*, London, 1887, p. 8.

[4] A condition described under the names "placental polyp" and "polypoid hæmatomata," but more correctly as "deciduoma."

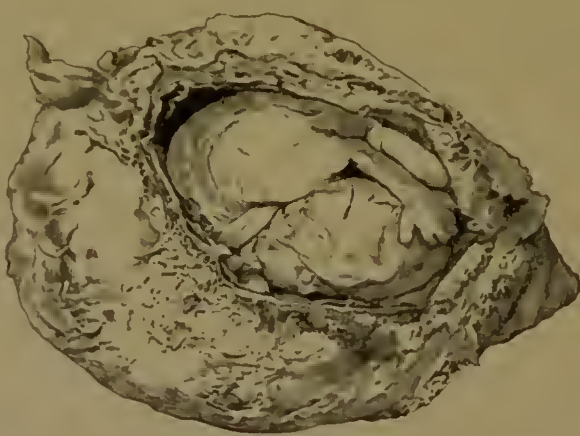
ened; as the embryo, enveloped by its amnion, is extruded without the decidua and chorion, or as the embryo, its delicate umbilical cord being ruptured, is expelled alone. The appearance of the embryo will of course differ with the different periods of pregnancy: if still enclosed in its amniotic sac, a thin-walled, transparent vesicle may be found

FIG. 190.

An Embryo in its Amniotic Sac (from the Medical Museum of the University of Pennsylvania).

floating in the blood or imbedded in a clot, and within the sac the embryo is seen floating in the liquor amnii. In other cases the ovum will resemble a ball of flesh, which on being opened discloses an embryo

FIG. 191.



An Embryo surrounded by Thickened Deciduous Membrane.

confined within a sac with very thick walls, composed mainly of greatly hypertrophied decidua. Or, again, the substance expelled from the uterus may be a fleshy mass, the deciduous membrane, in shape a cast of the uterine cavity, which on section reveals within itself an empty cavity. The embryo in these cases has either died and been absorbed, or else has been previously cast off unnoticed in the bloody discharge.

If the ovum proper is cast off entire—that is, with its chorional covering intact, without adherent shreds of deciduous membrane—it presents an appearance quite characteristic, especially if floated in water: the chorional villi show to the best advantage, giving the ovum very much the appearance, except for its color, of a chestnut bur.

Fig. 192.

Thickened Decidua, forming cast of uterine cavity.

Most frequently it is the embryo alone, or at most the ovum, in whole or in part, covered often by the ovular decidua, that is cast off, while the uterine decidua remains behind within the uterus.

Dührssen,[1] from a rich experience in the service of the Charité in Berlin, says that "the retention of portions of the decidua vera is not the exception, but the rule;" and Tarnier says that "ordinarily the uterine decidua remains adherent to the uterus." The retention of this membrane after abortion cannot be regarded with indifference, for the uterine mucous membrane in the early part of pregnancy, greatly hypertrophied and thickened, before it has undergone the physiological atrophy that begins in the third month, is very different from the delicate membrane which lines the uterus at term. This thickened uterine decidua, suddenly cut off from the greater part of its blood-supply by contraction of the uterine wall, becomes a mass of dead animal flesh within the uterus, and soon begins to putrefy, or else portions of the decidua attract an increased blood-supply, retain their original development, or even increase in size, forming new growths within the uterus which give rise to frequent and alarming hemorrhages.

Fig. 193.

A Section through the Median Line of the Placental Site, showing greatly hypertrophied placental decidua (specimen in the writer's possession, taken from a woman seven days post-partum).

It is this complication of abortion that often makes the prognosis uncertain, and is perhaps the main factor in raising the mortality after abortion to a point almost as high as that of childbirth at term. In New York City, between the years

[1] "Zur Pathologie und Therapie des Abortus," *Arch. f. Gyn.*, Bd. xxxi. H. 2.

1867 and 1875, inclusive, 197 deaths were reported as a result of abortion—a number doubtless far short of the truth. In the Rotunda Hospital of Dublin, during the mastership of Dr. Johnston, 234 abortions occurred, with but 1 death, and that from heart disease.[1] But of 120 cases treated in the clinic and polyclinic of the Charité in Berlin, 2 died.[2] Of 82 abortions in the Obstetrical and Gynecological Institute of Florence,[3] 5 resulted fatally to the women—a death-rate of 6 per per cent. In the Charité at Paris (1883–86) there were 57 cases of abortion without a death; and in the Maternité, 153 cases with 1 death (Tarnier). Hospital statistics, however, as to the death-rate after abortion are unsatisfactory. The reliable records of some large outdoor dispensary service would tend to throw light upon the matter. The thesis of Lechler, containing statistics of this kind, already referred to in a foot-note, is, unfortunately, inaccessible to me. But whatever might be the exact result of the statistics of large numbers of cases in general practice, it is certain that every abortion entails a certain amount of risk upon a woman, and therefore the mode of treatment that will best avoid the two chief dangers of abortion, hemorrhage and septicæmia, must be a subject of anxious consideration for every physician.

Diagnosis.—It may be necessary in cases of suspected abortion to determine the existence of pregnancy: that fact being established, it becomes necessary to distinguish between threatened abortion, inevitable abortion, and an abortion partially or wholly accomplished.

The Diagnosis of Threatened Abortion.—If a patient should present a history of suppression of the menses, perhaps for only one period; if it could be learned that she had been exposed to the possibility of impregnation; if there were, in a word, the signs of early pregnancy, and a hemorrhage should occur from the uterus, associated with more or less pain,—the supposition that an abortion was threatened would be certainly justified. Irregularities in menstruation, the suppression of the function from causes other than pregnancy, and its re-establishment by a profuse flow, accompanied by pain, might well arouse a suspicion of abortion. In these cases, however, the signs of pregnancy are wanting, and it is claimed that the blood comes away in a stream, and not by clots, and that the os will not be found patulous. This is by no means true of every case, however, and if the symptoms should be due to an effort of the uterus to expel a polypoid tumor, the case may so

[1] Lusk's *Obstetrics*, 1886, p. 313.

[2] Dührssen: *loc. cit.* This same author mentions the statistics of 520 cases of abortion collected in the inaugural thesis of Lechler (Berlin). Half of these, treated by active interference, showed 4 deaths—3 from intercurrent affections, 1 the result of abortion.

[3] Fasola: "82 aborti nel triennio 1883–85," *Annali di Ostet. e Gynecol.*, March, 1887.

closely resemble one of abortion that the diagnosis will only be made after the expulsion of the uterine contents or the dilatation of the os. In cases of doubt the diagnosis had better rest on abortion and the treatment be adapted to this idea.

The Diagnosis of Inevitable Abortion.—It is always desirable to determine when a threatened abortion becomes inevitable, for when its prevention is no longer possible the treatment should be radically altered. Unfortunately, however, the signs which usually denote an unavoidable expulsion of the ovum are not always to be depended upon. If there is persistent hemorrhage, abortion will usually occur, but even in spite of a bleeding which may continue for a considerable time or return at intervals during the whole duration of pregnancy, the case may go on to term. If the cervix becomes markedly softened and the os dilates, the ovum will ordinarily be cast off; and yet the os has dilated sufficiently to admit two fingers, but has again retracted, and pregnancy has pursued its course. If portions of the uterine contents should be expelled, it would seem that abortion was surely inevitable; but Playfair, Charpentier, and Doléris have reported cases in which pieces of decidua were expelled from the uterus without the interruption of pregnancy. In Playfair's case four or five fragments of decidua, each as large as a fifty-cent piece, were cast off in the third month of pregnancy as a result of the introduction of a sound into the uterus; but the woman went on to term. The only two conditions which can be said to render the abortion almost inevitable are the rupture of the membranes and the death of the embryo; but even were it possible to ascertain with certainty during the early months of pregnancy that the membranes were ruptured or that the embryo was dead, cases might be recalled where the liquor amnii was resupplied after puncture of the pregnant uterus with the trocar (Chiara), or many other cases might be collected of the retention of an ovum after the death of the embryo for months or an indefinite number of years. If, however, the hemorrhage is persistent; if the os dilates; if there is felt presenting within the os a cystic tumor, the ovum;[1] if the pain is considerable; and, above all, if portions of the ovum are expelled,—the abortion may be pronounced inevitable. Tarnier[2] calls attention to another sign which he believes to be valuable as indicating an unavoidable abortion. This is the effacement of the rather acute angle formed anteriorly between the neck and body of a pregnant uterus. The disappearance of this angle indicates a contraction of the longitudinal fibres of the uterus and a descent of the ovum.

The Diagnosis of an Abortion Partially or Wholly Accomplished.—It

[1] It is well to bear in mind, in this connection, the possibility of the cervical pregnancy of Rokitansky, already referred to, of which several cases have been reported.

[2] Tarnier and Cazeaux, vol. i. p. 574.

is always important to determine in a case diagnosticated as one of abortion whether a part or the whole of the uterine contents has been expelled; or, where there is doubt as to the nature of the case, the detection of characteristic portions of an ovum in the discharge will at once disclose the fact that a pregnancy has been interrupted. To make the diagnosis, then, of an abortion partially or wholly effected it is necessary to carefully examine everything discharged from the uterus: the clots should be floated in water, and should be carefully teased apart, when often, if the case is one of abortion, an embryo, either alone or more or less enveloped by its membranes, may be discovered, leaving, of course, no doubt as to the case. But frequently the embryo and ovum are so small that they are lost in the comparatively great volume of blood that surrounds them, or the discharges are removed from the patient and are not preserved. In such cases an internal digital examination will ordinarily serve to determine the true nature of the case. The os will usually be found patulous; the finger, passing into the cavity of the uterus, will detect shreds of deciduous membrane more or less closely attached to the uterine wall, and often a placenta, still adherent, or some portions of the fœtal membranes, may be plainly made out. If the abortion has been wholly accomplished—that is, if all the uterine contents, including the hypertrophied decidua, have been completely expelled—the uterus will be firmly contracted, the os retracted, and a digital examination of the uterine cavity will be difficult or impossible. Here the diagnosis must depend upon the history of the case, upon the examination of the discharge, upon the enlarged uterus—which does not at once return to its normal size—upon the lochial discharge, and upon the establishment of the milk secretion. This last phenomenon is all the more marked the later the date of pregnancy at which abortion or miscarriage occurs, and is more evident in multiparæ than in primiparæ; but Budin has observed a young girl in whom the menses were suppressed for only twenty days, and then returned as a profuse flow, who exhibited shortly afterward all the signs of commencing lactation.

In other cases the disappearance of all the presumptive signs of pregnancy, which had been before well marked, would justify the opinion that an abortion had occurred; but it might denote nothing more than the death of the embryo, which can be retained within the uterus for varying periods of time, and when cast off may give rise to unjust suspicions as to the woman's moral character. Thus, if a woman whose husband may have been absent many months should expel from her uterus an embryo corresponding perhaps to the second month of intra-uterine life, it by no means invariably follows that she has been unfaithful.[1]

[1] Tarnier et Budin: *op. cit.*, p. 499.

Finally, if in the early months of pregnancy there is hemorrhage and a discharge of decidnous membrane, it would be well, while making the digital examination, to feel on either side of the uterus for a tumor that might indicate a tubal pregnancy.

Miscarriage.—Much that has been said of abortion is applicable to miscarriage as well, but by the time pregnancy has reached a period from the fourth to the seventh month, it is not likely that the condition will be overlooked, so that one great difficulty in the diagnosis of abortion, the doubt as to the existence of pregnancy, does not, as a rule, obtain in cases of miscarriage. In these cases too it is easier to detect those two accidents which make the expulsion of the ovum almost inevitable—rupture of the membranes and the death of the fœtus—for the liquor amnii has reached such a quantity that its escape would almost always attract attention, while the death of the fœtus, followed by a cessation of fœtal movements and of growth in the uterus, by a disappearance of the reflex and psychical disturbances characteristic of pregnancy, and also perhaps by the appearance of the milk secretion, is not likely to pass unnoticed. The pain associated with miscarriage is greater than in abortion, and assumes the type of labor-pains; during the periodic contractions of the uterus the organ can be felt through the abdominal walls becoming hard and firm, and relaxing again as the pain passes off. The expulsion of the ovum resembles also a labor at term, as the fœtus usually is first expelled and the membranes and placenta follow after. As pregnancy advances this sequence becomes more and more the rule, but occasionally the ovum is cast off entire even at a late period of pregnancy. I have seen such an occurrence between the sixth and seventh months, and it has actually been reported to have occurred at term.

Miscarriage is chiefly distinguished from abortion by the formation of the placenta, and from premature labor by the fact that this organ is quite adherent to the uterine wall, and often fails to become detached after the expulsion of the fœtus, remaining wholly or in part adherent to the uterus, preventing proper contraction of the uterine muscle, and consequently giving rise to serious hemorrhages. And, moreover, those portions of the placenta that are detached from the uterus, if allowed to remain undisturbed in the uterine cavity, will almost surely putrefy, giving rise in time to pyæmia or sapræmia.

Prognosis of Abortion and Miscarriage.—The prognosis as regards the product of conception need not be considered, for its destruction is inevitable. Statistics have been already given showing that every abortion or miscarriage entails a certain amount of risk upon a woman. The hemorrhage, if rarely so great as to be immediately fatal, may by its persistence so weaken a woman that she quickly succumbs if attacked by any intercurrent affection, or the syncope produced by loss of blood may favor the formation of heart-clot. The retention of masses of decidua or of the placenta is often followed by the decomposition of these substances in utero, with fatal septicæmia as a result. Tetanus is another complication post-abortum, which will, in rare cases, help to raise the mortality of abortion.[1] Criminal abortions, with the additional risks of traumatism from the unskilful use of instruments and the probability of infection from unclean hands and implements, would show probably a very high rate of mortality if it were possible to collect accurate statistics; which, for obvious reasons, it is impossible to do. With, however, a thorough appreciation of the sources from which danger springs, and by the adoption of a treatment which will remove the possible causes of perilous complications, the death-rate of abortion should be reduced to the minimum.

Treatment.—If a pregnant woman presents any of the conditions which a physician's experience or knowledge teaches him may lead to the premature interruption of pregnancy, the treatment of these conditions will constitute the preventive treatment of abortion. Much has been said upon this subject when the diseases of the embryo and fœtus and of the ovum were under consideration. The proper conduct to pursue in the other complications of pregnancy just described may be briefly indicated.

In cases of irritable uterus the woman must be jealously guarded against any nervous shock, undue physical exertion, errors in diet, sexual intercourse—anything, in a word, that would furnish the uterus an excuse for throwing off its contents. In exaggerated cases of this condition prolonged rest in bed, especially at the time corresponding to the menstrual periods or perhaps for the whole duration of pregnancy, may be necessary to secure the birth of a mature infant. If the pregnant uterus is displaced downward or backward, it must be restored to its proper position, and be kept in place by a suitable pessary until its increasing size prevents it again descending or falling backward. If there should be uncontrollable vomiting or coughing, these conditions must be treated according to well-known principles. Asthma, which in some cases will determine a premature interruption of pregnancy, is best treated by change of climate.[2] In general muscular spasms, as in eclampsia, cholæmia, chorea, epilepsy, hysteria, and tetany, the convulsions must be combated by appropriate remedies. The infectious and febrile diseases of pregnancy must be managed on general principles, without special regard to the danger of abortion, which is often unavoidable. Chronic metritis and endometritis, fibro-myomata of the uterus, lacerated cervix, perimetritis and cellulitis, disease of a tube or an ovary, must be treated before impregnation occurs. If, however, in spite of

[1] For 21 cases of tetanus after abortion, see Bennington: *British Gyn. Journ.*, 1885.

[2] See note by Harris to Playfair's *Midwifery*, p. 243.

every precaution, the signs of threatened abortion manifest themselves, the treatment resolves itself into—(1) the treatment of threatened abortion, (2) the treatment (if necessary) of inevitable abortion, and (3) the treatment of the woman post-abortum.

The Treatment of Threatened Abortion.—The two main principles of the treatment adopted to avert a threatened abortion should be perfect rest and the administration of drugs that will diminish nervous sensibility and weaken muscular action. The first can only be secured in bed in a perfectly supine position: the room should be darkened and kept quiet, that the rest may be mental as well as physical. The second object of the treatment can be accomplished by giving opium, bromide of potassium, and chloral. Opium enjoys a well-deserved reputation in these cases; many instances might be cited of its beneficent working. It may be administered by the mouth as laudanum, hypodermatically as morphia, or by the rectum; it seems to be the custom in France to inject laudanum into the rectum—a clumsy method of accomplishing what is better effected by our suppositories. Women on the verge of abortion display usually a remarkable tolerance of opium, and to be effective the dose must often be large: as much as a drachm or more of laudanum has been given within twenty-four hours without ill effect, but of course the patient must in such cases be carefully observed. With the opium it is often of advantage to combine moderate doses of chloral and bromide of potassium. Viburnum prunifolium[1] has of late years been much vaunted as almost a specific in the prevention of abortion, and its use has become very general throughout this country. The verdict in regard to this drug is, on the whole, favorable: Lusk speaks well of it; in England it has been tried by Campbell[2] and Napier,[3] who both recommend it; and its employment seems to have spread even to Russia.[4] It may be given, in the form of a fluid extract, in teaspoonful doses.[5]

Treatment of Inevitable Abortion.—As soon as all hope of arresting a threatened abortion is destroyed by the appearance of signs pointing to the unavoidable expulsion of the uterine contents, the treatment must be radically altered. Absolute rest is no longer necessary, while the administration of drugs that diminish sensibility and weaken muscular action is positively harmful, for it prolongs a process which in the interests of the patient were best completed as speedily as possible. But in many cases the woman will linger on, perhaps for days, before

[1] Jenks: "Viburnum Prunifolium," *Tr. Am. Gyn. Soc.*, vol. i. p. 130.

[2] *Br. Med. Journ.*, 1886, i. p. 391.

[3] *Ibid.*, p. 489.

[4] Reference in *Index Med.*, 1887, Lvov.

[5] Negri has recently recommended large doses of asafœtida in cases where there had previously been a tendency to abort or to give birth to dead children. Great virtue is claimed for this drug, but it has not yet been given a sufficient trial to warrant an expression of opinion in regard to it.

the greater part of the uterine contents is expelled, and it may be weeks before she is rid of the thickened decidua, which usually remains behind, or of the adherent placenta, which is often retained in the uterus after the escape of the embryo and the rest of the ovum; and all this time there may be recurring hemorrhages of an alarming character or a constant dribbling of blood, and the lochial discharge becomes abundant, and is perhaps ill-smelling. Now, in such a case, the question naturally arises as to the advisability of interference, either early in the progress of the case, in order to bring it to a speedy termination and to thoroughly clear the uterine cavity of substances that might give rise to future trouble, or at least when the hemorrhages become alarming and the discharges offensive. This question receives different answers from authorities equally entitled to respectful attention.

If the hemorrhage is severe before the os is at all dilated or any portion of the ovum discharged, there is no difference of opinion as to the necessity of controlling the bleeding. This is best effected by a vaginal tampon of baked cotton,[1] made up into balls about the size of a walnut, packed closely in the vaginal vault and in front of the cervix until the vagina is filled in its upper third. A Sims speculum will facilitate the introduction of the tampons. Braun's colpeurynter, which is recommended so highly by its inventor for this purpose, has not, and probably will not, find general acceptance. If the woman is so anæmic that the loss of even a small quantity of blood is of moment, it would be of advantage often to tampon the cervical canal, or, better still, the whole uterine cavity, employing for this purpose either little balls of iodoformed cotton, as Vulliet advises, or strips of iodoform gauze, as Dührssen[2] does in these cases. Vulliet's method has done me good service in controlling severe hemorrhages from the body of the uterus in cancerous disease of that organ, and would probably be found very useful in the hemorrhage of abortions, especially in the early months of pregnancy. The vaginal tampon should be removed after six or eight hours, and replaced by a fresh one if necessary, but often, as the first one is removed, along with it will come the ovum or fœtus, and the immediate symptoms may in great part subside. But the uterus may not yet be empty; in the early months the large mass of deciduous membrane has almost certainly remained behind in the uterine cavity; later, the placenta will frequently be retained. Here it is that there is so much difference of opinion as to the proper course to pursue. Whether

[1] Cotton baked in an oven till it becomes a little singed and well sterilized. The use of antiseptic cotton is scarcely advisable, for the quantity required for an efficient tampon is so large that the danger from absorption of the germicide with which it is impregnated cannot be overlooked.

[2] *Loc. cit.*

now to treat the case expectantly until serious symptoms develop, or to remove at once the substances in the uterus which may give rise to future complications, is a problem that must frequently confront every practitioner. In France the more conservative course is almost universally adopted. Tarnier quite recently speaks strongly in favor of avoiding any interference even if the whole placenta is known to be in the uterus; he insists that the uterus should be allowed time to expel the foreign substance in the course of nature, but that in the mean time antiseptic injections should be systematically employed: if, however, alarming hemorrhage appears or the discharge becomes foul, more active measures are counselled. Tarnier points to the statistics of the Charité and the Maternité, in which he saw 46 cases of retained placentæ after abortion, with only 1 death, and that from pneumonia; but the statistics of the hospital in Florence already referred to, in which pretty much the same plan seems to be pursued as that advocated by Tarnier, show a death-rate after abortion of 6 per cent. Guéniot was for some time the only prominent dissenter from the general practice in France, but recently he has been joined by Doléris,[1] who recommends active interference in retention of the placenta, but counsels a conservative course when the membranes are retained. In Germany the same difference of opinion may be met with in regard to the treatment of inevitable abortion, but the majority lean to a more active course. Schroeder[2] says that although the abortion must not be hastened until there is some dilatation of the os and until the ovum is pretty well separated from the uterus, then the uterine contents can often, in the early months at least, be pressed out by Hoening's method, squeezing the uterus between two fingers in the vaginal vault and those of the other hand on the abdomen. If any portion of the ovum should remain behind, it must, says this author, be invariably removed, even should the cervix have to be split on both sides to reach it. If the retained substance is the hypertrophied decidua of early pregnancy, Schroeder advises the use of the sharp curette to remove it. Fehling[3] and Schwarz[4] are also warm advocates of an active treatment. Braun[5] rather deprecates the employment of instruments in these cases, but advises the use of the finger, whenever possible, to remove the ovum. Dohrn,[6] on the other hand, carries the expectant plan of treatment to its farthest limits, and Winckel attempts no active interference.[7]

In this country the views of Mundé are well known. "The future safety of the patient," says this authority, "demands that the secun-

[1] *Nouvelles Archives d'Obstet.*, 1886, p. 318.
[2] *Geburtshülfe*, S. 482.
[3] *Archiv f. Gyn.*, Bd. xiii. S. 222.
[4] *Samml. klinischer Vorträge.*
[5] *Lehrbuch der Gesammten Gynäk.*, 2te Aufl. S. 614.
[6] *Samml. klin. Vortr.*, 42.
[7] Practice observed by the writer while volunteer interne in the Frauenklinik at Munich.

dines should be at once removed after the expulsion of the fœtus in every case in which such removal can be accomplished without force sufficient to injure the woman." Parvin, whose opinion must always command respect, recommends, on the other hand, non-interference with the cavity of the uterus in abortion unless at some later period hemorrhages occur or septicæmia is threatened.

Now, in determining this question in regard to the treatment of inevitable abortion, an answer to the following questions is desirable: Is the retention of decidua, fœtal membranes, or placenta after abortion fraught with any danger to a woman? and, Is the immediate removal of the secundines after abortion necessarily a violent or dangerous procedure? Cases are reported, it is true, in which the retention of the placenta was followed by no immediate symptoms; but will any one say that under such circumstances a woman is healthy and free from danger? The following case, abstracted from Tarnier and Cazeaux, is instructive in this connection, for Tarnier, be it recollected, is one of the foremost advocates of the expectant treatment: the italics in the quotation are mine: "During the first five days the patient did very well, but on the sixth *I thought I detected a slight odor in the lochia,* and at three o'clock in the afternoon a violent chill came on which lasted an hour. . . . . This unfortunate lady died on the tenth day. At the post-mortem examination we found the uterine tissue softened and *its cavity filled by the putrefied and still adherent placenta.*" Note that on the sixth day there was a mere suspicion of a putrid odor to the discharge, and yet at that very time this woman's life was probably doomed.

The question as to the danger of active interference after abortion can only be answered by those who have adopted this plan of treatment in a skilful and judicious manner. Dührssen[1] has lately reported 150 cases of abortion treated by a thorough and immediate clearing out of the uterine cavity, with only 2 deaths, and these in no manner attributable to the treatment adopted. I have used the curette in many cases post-partum et abortum, and have never seen the slightest ill effects from it; on the contrary, the treatment proved invariably beneficial. It must be acknowledged, however, that in the hands of general practitioners, unaccustomed to gynecological manœuvres, the curette in the puerperal uterus may prove a dangerous instrument. A most distressing case has recently occurred in Berlin,[2] where a practitioner caused the death of a patient by perforating her uterus with a curette after an abortion, in consequence of which this unfortunate physician was sentenced to imprisonment. There will be many, therefore, who will be indisposed to resort to instrumental interference after abortion; and, moreover, in a choice of the treatment to be adopted much depends upon the temperament of the physician as

[1] *Loc. cit.*

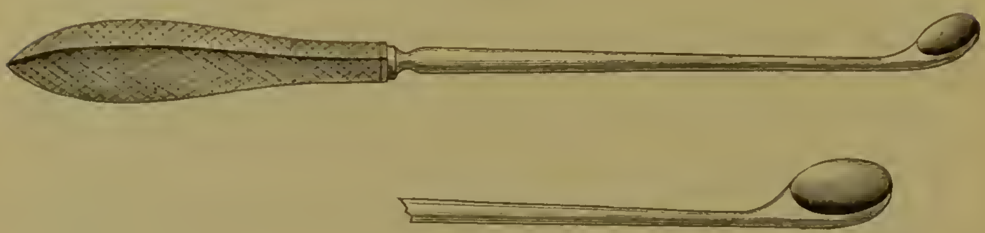
[2] *Deutsche med. Wochenschr.*, 1886, 28, xv.

well as upon the circumstances of the case. Consequently, in a work of this kind it is fairer to give a sketch of both plans of treatment.

Expectant Treatment.—When an abortion becomes inevitable, ergot may be substituted for the drugs that have been employed to inhibit muscular action; if there is much bleeding, tampons are to be used in the manner already indicated, and removed from time to time until the ovum is expelled, or else so well separated from the uterine wall that it may be gently expressed or easily extracted by the fingers. The greatest care must be exercised to avoid rupture of the membranes, for this will probably lead to the retention of a portion of the ovum, whereas the expulsion of the ovum *en bloc* is particularly desirable in cases managed after this fashion. If a part of the embryo or its appendages should remain behind in the uterus, the woman is to be kept quiet in bed, small doses of ergot are to be administered, and the vagina and, if possible, the uterine cavity are to be kept aseptic by injections of some effective germicide, preferably bichloride of mercury in solution. The folly of neglecting this precaution until the substance in utero begins to putrefy is shown by the case already quoted. If, in spite of every precaution, the discharge becomes foul, or if hemorrhages occur, all are now agreed that the uterine cavity is to be cleared out. The manner of doing this will be indicated later.

Active Treatment.—The first step of this plan of treatment resembles that already described. The tampon is used to control bleeding, and as soon as the dilatation of the os is sufficiently advanced to admit a finger, efforts are made, in early abortions, to turn out the ovum by sweeping the fingers around it, and then extracting it, with the finger crooked behind it like a hook; or Hoening's method of expression may be tried. The proposition of Dührssen to treat the ovum before the third month like a polypoid tumor, and so soon as the os is slightly dilated to introduce a curette and incontinently clear out the uterine contents, is, to the writer's mind, not a bad one. The ovum being wholly or in part expelled, everything left behind in the uterine cavity, whether thickened decidua or placental tissue, is to be extracted. Various means have been proposed for accomplishing this purpose. For an adherent placenta nothing is better, in the writer's opinion, than the finger, which can be made to reach the fundus, the patient being anæsthetized if necessary, by pressing the uterus down from above through the abdominal walls. By the finger the placenta is peeled off from the uterine wall, and afterward easily extracted. Often so much force is necessary to do this that the use of an unyielding and insensible instrument is not advisable. To clear out the thickened decidua, which almost invariably remains behind in early abortions, nothing is so good as a curette, of which many varieties have been proposed for this purpose. Mundé's instrument demands a widely-opened os, and is more effective as an extractor of substances loose within the uterus than as an instrument designed to separate membrane or placenta adherent to the uterine wall. Simon's spoon has been very satisfactory to me when the os is small and the uterine cavity is not

Fig. 194.



Simon's Spoon.

too large. For the uterus post-partum or after miscarriages I have an instrument somewhat resembling Mundé's in shape, but with a distinctly scraping edge.[1] Dührssen has demonstrated that the decidua removed from the uterus in this manner is not rudely torn off, but is separated in a natural manner in the cellular layer. If the os is so

Fig. 195.

A Cervical Bougie.

retracted that neither a finger nor an instrument can be introduced, the introduction of Hegar's graduated hard-rubber cervical dilators will obviate the difficulty.

After the uterine cavity is cleared out, it should be disinfected by a gentle stream of antiseptic solution introduced preferably through a Bozeman's catheter.

The After-treatment of Abortion.—If an active treatment has been pursued, the after-treatment will be very simple, for the lochial discharge in these cases is slight and the involution of the uterus rapid. Until this latter condition is perfected the woman, of course, should be confined to bed. The after-treatment when an expectant plan has been pursued has already been indicated. Should septicæmia develop, it is to be managed on the same principles that govern the treatment of this condition after delivery at term.

[1] Described in the *Am. Journ. Obstet.*, Dec., 1887.

THE PHYSIOLOGY OF PREGNANCY.

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Pregnancy inaugurates a series of structural changes, with corresponding modifications of function, in every organ and tissue of the body. In the study of the natural history of this process, as it affects the maternal organism, it is convenient to consider, first, the local changes; and second, the general changes.

I. Changes in the Genitalia and Neighboring Organs.

Changes in the Uterus.

Of all the changes in the maternal organism caused by pregnancy, the first in point of time, the most noticeable, and the most important occur in the uterus. Many years ago Swammerdam[1] christened this organ the *miraculum naturæ*, and modern science fully indorses the apophthegm.

The normal relations of the non-gravid womb are modified under the influence of the nutritive energy imparted by the fecundated ovum as to structure, volume, weight, form, position, direction, topography, and function.

Structure.—The increase in the size of the uterus is due largely to modifications of its musculature. The original length of the muscular fibres is 0.045–0.09 mm., with a breadth of 0.0074–0.015 mm. They grow rapidly, attaining from seven to eleven times their original length and from two to five times their original breadth (Kölliker). At the same time, new non-striated fibres are developed from embryonic muscle-cells stored up especially in the inner layers of the uterine wall. It has been asserted that when this store of embryonal elements has once been used up, either pregnancy does not occur again or it is not completed (Spiegelberg). The hypertrophy of the muscular elements continues throughout pregnancy, while the hyperplasia is apparently limited to the first five months. The sparse connective tissue between the

[1] Joh. Swammerdam, 1672: *Miraculum naturæ s. muliebris fabrica.*

muscular fibres undergoes proliferation, becomes more succulent, and toward the end of pregnancy shows fibrillæ.

The arrangement of the muscular fasciculi in the gravid womb—obviously a difficult study—is still the subject of controversy. Hélie,[1] after twelve years' investigation, concludes that three layers or coats are distinctly separable into an external, a middle, and an internal lamella.

1. The external layer, composed of alternating planes of longitudinal and transverse planes, covers the corpus and fundus like a veil from the cervical junction in front to a lower point posteriorly. As this layer approaches the fundus its lateral fibres curve outward and are prolonged along the round ligaments, tubes, ovarian and broad ligaments, enveloping these structures in a sort of muscular drapery. This layer is intimately adherent to the peritoneum.

2. The middle or vascular layer, constituting the bulk of the musculature of the corpus, is composed of fasciculi of variable size which cross each other in all directions. Through this intricate, arciform arrangement of the fasciculi the veins, reduced to the intima, run in true contractile channels. The arteries, however, are separated from the encircling muscular bands by connective tissue, so that they are enabled to glide in the rings. The functional importance of this structural peculiarity is great, since it affords a satisfactory explanation of the mechanism by which hemorrhage after labor is in part prevented.

3. The internal layer. On the inner aspect of the anterior and posterior uterine walls a triangular stratum of muscular fibres is visible, whose base corresponds to a line drawn transversely between the tubal ostia, and whose apex descends to the os internum. Between the sides of these triangles muscular fasciculi run transversely, constituting rings. Orbicular bands are arranged around the tubal ostia and internal os immediately beneath the lamella just described.

The musculature of the cervix is derived exclusively from the external and internal layers, and is composed chiefly of transversely annular fibres.

While it is possible to dissect off the three layers just mentioned, it must be borne in mind that fibres pass from one stratum to another, binding all of them together into one hollow muscle.

The researches of Kreitzer,[2] Luschka,[3] and Henle[4] correspond in general with Hélie's observations. Von Hoffmann[5] describes the arrange-

[1] *Recherches sur la Disposition des Fibres musculaires de l' Uterus dévellopé par la Grossesse*, Paris, 1864.

[2] *Petersburger med. Zeitschrift*, 1871, p. 113.

[3] *Die Anatomie des Menschlichen Beckens*, Tübingen, 1864.

[4] *Eingeweidelehre*, 1873, p. 476.

[5] "Morpholog. Untersuch. über die Muskul. des Gebärmutterkörpers," *Zeitschrift f. Geburtsh. und Frauenkrankheiten*, 1876, p. 448.

ment of the lamellæ in accordance with the view that the uterine muscular substance is derived by a transformation of the musculature of the tubal endings. The important investigations of C. Ruge[1] throw much light upon the subject. In the pregnant uterus at term the muscular lamellæ lie upon each other in strata which, having their

Fig. 196.

Fig. 197.

Fig. 198.

Fig. 196.—Longitudinal Section through the Lower Uterine Segment of a Parturient Uterus.
Fig. 197.—The Same Section, with individual muscle-lamellæ drawn apart.
Fig. 198.—Longitudinal Section of same Character, with indication of the shortened musculature.
O. I., orificium internum; C. R., contraction-ring (C. Ruge, Schroeder).

origin in the peritoneum and being inserted in the decidua, pursue a course, from upward and outward, downward and inward. The individual lamellæ, superimposed upon each other like tiles, are mutually bound together by bands of muscular fibres which pass obliquely from one principal stratum to the plane immediately beneath, so that when the bundles are somewhat stretched apart in dissection, they form long drawn-out rhomboid figures.

[1] *Archiv f. Gynäk.*, xv. p. 262; *Zeitschrift. f. Geburtsh. u. Gynäk.*, v. p. 149; Keuller, *Diss. Inaug.*, Berlin, 1880.

Bayer's[1] observations constitute the most recent important contributions to the literature of the subject. After a laborious study extending through a considerable period of time, Bayer draws the following conclusions:

1. "The internal longitudinal fibres of the tubes form the largest part of the submucous muscular layer, while their external longitudinal layer forms a part of the external fasciculi of the uterus. The circular layer of the oviducts, on the other hand, assists in the formation of the middle coat.

2. "The chief mass of the musculature of the lower pole of the corpus and of the cervix is developed from the *retractors*. The lower portion of the posterior wall of the corpus in its greatest thickness, a thinner and higher zone of the anterior wall, the entire posterior and lateral wall of the cervix, as well as the anterior lip and the lower portion of the cervix immediately above, have this origin.

3. "The rest of the uterine musculature is derived from the radiating fibres of the gubernaculum of Hunter—the chief mass of the posterior wall of the corpus downward to the fibres of the retractors and the muscle-bundles surrounding in different strata the tubal angles of the womb from the ovarian ligaments, the external layer of the anterior wall of the corpus and lower portion of the cervix, and the entire supravaginal portion, from the round ligament. The middle layer of the fundus is formed from both ligaments in common.

"It will thus be seen that a division of the entire musculature into three or more definite strata is not feasible, since the arrangement of the fibre-masses is diverse in different parts of the uterus. Its construction can only be understood by examining the individual portions of the uterus separately.

"In a word, the entire uterus contains almost everywhere sphincter fibres. The entire cervix ought to be comprehended as a sort of sphincter; however, its sphincter action is opposed to the influence of the remaining systems of fibres. During the expansion of the uterus this sphincter is broken, since the anterior segments of the ring of the retractors are drawn apart and elevated with the increase in breadth of the leaves of the round ligament; the superior boundary of the sphincter will always lie at the upper end of the closed cervical canal. In the lower section of the cervix the sphincter action continues even after the expansion of the uterus, and is only removed by the pressure of the descending contents of the uterus, because it depends here upon the elasticity of the masses of connective tissue."

The practical importance of adequate knowledge of the arrangement of the uterine musculature during pregnancy may not be at once appa-

[1] "Zur Physiologischen und Pathologischen Morphologie der Gebärmutter," p. 427, *Gynäkologische Klinik*, Strassburg, 1885.

rent. Brief reflection upon the modern theory of labor, however, must convince the most casual reader of its utility.

The transformation of the decidua of menstruation into the decidua of pregnancy is fully discussed in another article. It may not be amiss, however, to mention, in passing, a new hypothesis of menstruation, or rather the revival of an old one, which if demonstrated will modify materially the views now current as to the structural and functional changes in the uterine mucous membrane during gestation. Arthur W. Johnstone[1] has arrived at the conclusion "that in the ordinary acceptation of the term the endometrium, above the internal os, is not a 'mucous membrane,' but belongs to the so-called 'adenoid' tissues, and that menstruation is for it exactly what the lymph-stream is to the lymph-gland or the blood-current to the spleen." The "menstrual organ" consists of a single layer of epithelial cells which slips into every reduplication of the glandular canals, thus giving a protecting coat to the soft protoplasmic tissue beneath, the essential element. When the epithelium is stripped off, the endometrium presents to view a tissue suggestive of the lymph-glands as regards structure and function. Haller and Hunter regarded menstruation as a secretion. Ercolani hinted at this view. Dewees and Hodge vigorously upheld a doctrine not dissimilar to the hypothesis now proposed by Johnstone.

The arteries increase in length, circumference, and number. They become more tortuous—a fact which proves their increase in length is not due to diminution in the number of flexures (Jacquemier). The branches are much larger than the trunks, and are found in greatest abundance near the placental site. They terminate directly in the parenchyma of the after-birth (utero-placental arteries) and adjacent veins, or, in other regions, in capillaries. Their course becomes especially spiral or corkscrew-like as they approach the placenta—an arrangement which facilitates the closure of the canals by uterine contractions. The arteries are surrounded by a thin lamella of connective tissue, so that they glide in the rings of the uterine muscular fibres. The uterine artery, a branch of the anterior trunk of the internal iliac, and the ovarian, a branch from the aorta of both sides, anastomose, and form a vast network of vessels situated nearer to the peritoneal than to the mucous coat. One of the most important anastomoses, a branch from the uterine artery to the ovarian, runs nearly parallel to the epigastric and attains a size larger than the radial. Glénard designates this vessel the puerperal artery, and erroneously regards it as the seat of the uterine souffle.

The ovarian vein increases to the size of the internal or external iliac, measuring 3–4 mm. in diameter (Jacquemier). The uterine plexus of veins is converted into a system of enormous sinuses located in the

[1] "The Menstrual Organ," *The British Gynæcological Journal*, part vii., 1886, p. 292.

middle muscular layer and beneath the placental site. These sinuses communicate freely with each other, and at term are large enough to admit the tip of the little finger. The veins are valveless, but the true contractile channels of the middle muscular tunic through which they run, reduced to the intima, perform the functions of valves. The utero-placental veins have been described when the structure of the placenta was under consideration.

The uterine lymphatic system undergoes hypertrophic and hyperplastic changes in all form-elements analogous in kind and degree to those of the blood-vessels. In the light of recent discoveries the whole intra-uterine expanse may be viewed as one vast lymph-sinus (Spiegelberg, Johnstone). Originating in the lymph-spaces surrounding the utricular glands and blood-vessels, the lymphatic tubes, frequently the size of a goose-quill, pass through the muscularis, communicate with the lymph lacunæ and spaces of the region, and are collected together in a plexus beneath the peritoneum, especially over the fundus and along the sides of the uterus. The lymphatics of the corpus and fundus join the lumbar glands, while those of the cervix communicate with the pelvic glands (Leopold). These changes are of functional importance in the evolution and involution of the womb, and explain in part the disposition to the absorption of septic matter of the pregnant, parturient, and puerperal organ.

Once the subject of controversy, it has now been demonstrated that there is a new formation of nervous tissue in the pregnant uterus. The cervical ganglion becomes enormously enlarged, increasing in size four-fold until it attains a length of 5 cm. and a breadth of 3.79 cm. (Frankenhäuser). The uterine nerves grow in length and circumference, the increase in thickness being largely due, however, to the proliferation of the neurilemma. They terminate in the nuclei of the muscular fibre-cells or in the submucous ganglia. Reimann[1] has pointed out the physiological necessity for ganglia in the uterine walls, while their actual presence in the inner muscular tunic has been demonstrated by another observer.[2]

The sensibility of the uterus is probably not altered during pregnancy, and remains limited to the general perception of external stimuli. The endometrium evinces the highest degree of sensibility; the vaginal portion the least.

Volume, Capacity, and Weight.—Corresponding to the textural changes in the gravid uterus, an enormous increase in volume, capacity, and weight ensues, the resultant of very great eccentric hypertrophy and passive distension by the fecundated ovum. During the first half of gestation the increase in these relations is due to a

[1] *Arch. f. Gyn.*, Bd. ii. Heft 1, p. 97, 1871.

[2] Spiegelberg, *Mon. f. Geb.*, xxiv. pp. 12, 13.

true eccentric hypertrophy, since the ovum is too small to mechanically distend the uterus. Moreover, the analogous changes occur in the uterus during the same period in cases of ectopic gestation. Then, too, in cases of pregnancy in the double uterus, the empty horn undergoes hypertrophy and hyperplasia. Passive distension by the ovum, however, is an important factor during the second half of pregnancy, since the muscular parietes grow progressively thinner, until at term the thickness of the fundus is only 1 cm., equal to, or even less than, the thickness of the virgin fundus. Even at the end of the fifth month Schroeder[1] has observed the thickness of the fundus reduced to 3–5 mm.

At term the uterus, 6.5 cm. long in the virgin state, measures 35 cm. in length, 24 cm. in breadth, 23 cm. in depth (Spiegelberg). Sir James Y. Simpson gives the following measurements: length, 12–15 inches; breadth, 9–10 inches; thickness, 6–8 inches.

Farre[2] and Tanner have constructed the following table, showing the rate of increase in the size of the uterus according to the months of gestation:

	Length.		Breadth.	
	Inches.	Cm.	Inches.	Cm.
End of 3 months	4½–5	11.3–12.6	4	10.1
" 4 "	5½–6	13.8–15.1	5	12.6
" 5 "	6–7	15.1–17.6	5½	13.9
" 6 "	8-9	20.1–22.6	6½	16.4
" 7 "	10	25.2	7½	18.9
" 8 "	11	27.7	8	20.2
" 9 "	12	30.2	9	22.7

Sir James Y. Simpson estimates the surface of the unimpregnated uterus at 5–6 square inches, with a capacity of 1 cubic inch; at term its surface measures 350 square inches, with a capacity of 400 cubic inches. Krause states that the capacity is increased 519 times.

The weight of the uterus at term varies from 900 to 1200 grams. Moreau has observed a specimen weighing 1700 grams. Assuming the weight of the non-gravid nulliparous organ to be 42 grams, the parous womb 55 grams, it is obvious that the weight of the gravid uterus at term is twenty-one to twenty-four times as great as in the unimpregnated state (Meckel).

Form.—During the first three months the flattened, pyriform shape of the uterus undergoes slight alterations. There is a relative increase in the antero-posterior diameter, so that the contour of the organ has been aptly compared to that of a fig. The fundus and upper portion of the corpus—corresponding to the site of the ovum—gradually begin to grow in the direction of the transverse and antero-posterior axes, so

[1] *Lehrb. d. Geburtshülfe*, p. 88, Bonn, 1884.

[2] "The Uterus and its Appendages," *Todd's Cyclop. of Anat. and Physiol.*, p. 645.

that during the second trimester the uterus assumes the form of a short ovoid or a flattened spheroid, with the cervix at the most dependent part but little changed. In consequence of the inclination forward of the top-heavy fundus, the yielding nature of the anterior abdominal parietes, and the rigid, unyielding character of the support of the posterior uterine wall, the angle at the junction of the cervix with the corpus is rendered more acute and a physiological anteflexion is produced. During the third trimester growth in the direction of the longitudinal axis preponderates, and the uterus acquires an ovoid shape, with the cervix corresponding to the smaller end. The form of the uterus, however, as remarked by Spiegelberg, is not constant, especially during the last three months. Its contour depends upon a variety of conditions, such as the posture of the woman, the volume of the uterine contents, the presentation of the fœtus, the tension of the organ, and, finally, upon its primitive formation. The form of the uterus is accordingly more variable, as a rule, in multiparæ than in primiparæ.

Position.—During the early part of the first trimester the uterus sinks in the pelvic cavity as the result of increased weight augmented by the pressure of the intestinal mass upon the enlarged area of the fundus. This descent causes a slight flattening of the hypogastrium, of some significance in the diagnosis of pregnancy. The phenomenon, as pointed out by Spiegelberg, Tarnier, and others, is by no means constant. Toward the end of the first trimester the uterus, no longer capable of accommodation within the pelvic cavity, begins to rise above the brim into the cavity of the abdomen. At the end of the third month the fundus is about one centimeter above the pubes. It reaches or passes slightly above the plane of the umbilicus during the second trimester, and distends the epigastrium at the thirty-eighth week, the vaginal portion frequently being above the plane of the inlet as early as the twenty-eighth week. About the last fortnight, in primiparæ, the womb descends, owing to the engagement of the head and lower uterine segment within the pelvic cavity.

Direction.—The uterus in passing up into the abdominal cavity is inclined forward against the less resistant anterior abdominal parietes by the lumbar spine, following in its growth the general direction of the axis of the pelvic inlet. In eight (Cazeaux) out of ten cases it deviates to the right of the median line, and is slightly rotated on its longitudinal axis, so that the left lateral surface is brought somewhat forward. This right lateral obliquity and axial rotation has been ascribed to a great variety of causes: the relatively frequent insertion of the placenta on the right side of the uterus (Levret); the presence of the descending colon and sigmoid flexure, often filled with scybala (Desormeaux, Dohrn); the habit of lying upon the right side; the relative shortness and greater development of the right round ligament (Boivin); the mode of the evolution of the uterus (Pajot, Spiegelberg).

These changes in direction are of considerable practical importance. The uterine bruit is usually heard most distinctly over the left lateral surface of the uterus. The latero-version may interfere with the engagement and descent of the presenting part, requiring a change in the posture of the woman. Then in the performance of the Cæsarean section it is necessary to correct these changes in order to bring the incisions through the abdominal wall and the uterus into proper relation.

Topographical Relations.—The configuration and relations of the uterus in the abdominal cavity are subject to numerous and important changes, since it is a soft, relaxed sac, with only relative fixation at its inferior extremity. In the erect posture the fundus falls forward against the anterior abdominal wall, bulging it outward, since the centre of gravity is far in front of the symphysis. The antero-posterior diameter of the abdominal cavity, on a level with the fifth lumbar vertebra, now measures about two-thirds of the thickness of the entire body (Spiegelberg). In the horizontal decubitus the uterus rests upon the spine, with an increase in the longitudinal and diminution in the antero-posterior axes.

The topographical relations of the pregnant uterus have been accurately studied within a recent period by the comparison of plane frozen sections of women dying during gestation. Waldeyer's[1] observations are of especial interest. He describes the median sagittal section of the uterus of a woman dying within a few days of term as a regular oval, with the larger end corresponding to the fundus. The anterior convex surface rests below on the anterior half of the pelvis, the empty bladder lying behind the symphysis. The lower three-fourths of this anterior convex surface is applied to the abdominal wall from the symphysis to a distance of one hand's breadth above the navel. The fundus, on a level with the second lumbar vertebra, corresponding to B. S. Schultze's observation, is covered by coils of the small intestine and transverse portion of the duodenum, which separate it from the pancreas, stomach, transverse colon, and liver. The posterior surface is concave, corresponding to the convexity of the curve of the lumbar spine. It is in relation, from above downward, with the abdominal aorta, left common iliac vein, fifth lumbar vertebra, and sigmoid flexure.

Waldeyer's investigations agree in the main with the results arrived at by Braune,[2] Schroeder,[3] and Chiari.[4]

[1] *Medianschnitt einer Hochschwangeren, etc.*, Bonn, 1886, p. 25.

[2] *Die Lage des Uterus und Fötus am Ende der Schwangerschaft*, Leipsic, 1872.

[3] *Der Schwangere und Kreissende Uterus*, Bonn, 1886.

[4] *Ueber die Topographischen Verhältnisse des Genitales einer Inter Partum Verstorbenen Primipara*, Wien, 1885.

All four observers unite in the opinion that the intestines are pushed above and to the sides of the uterus, that viscus pressing more or less directly upon the great abdominal vessels and ureters. This fact is of obvious significance in connection with the pressure theory of Bright's disease during pregnancy. Then the location of the intestines at so great a distance from the anterior convexity of the uterus indicates that when the bladder is empty there is little danger of wounding these organs or of their escape in the primary incision of Cæsarean section. Their functions are not directly influenced by uterine pressure. The respiratory movements of the diaphragm, on the other hand, are limited, in some degree, especially toward the end of gestation.

Function.—The chief change in uterine function consists, of course, in the transformation of the menstrual organ into an adequate receptaculum for the development and expulsion of the fœtus. There is little doubt but that menstruation is suspended with the commencement of pregnancy. If ovulation did occur throughout gestation, we should expect to find, instead of one, several corpora lutea vera. Extended observation has failed to reveal more than one corpus luteum verum after the birth of a single child (Gusserow) or to show recently ruptured ovisacs (Virchow). Moreover, the researches of Slavjansky have demonstrated that in so-called pseudo-menstruation the changes in the ovaries and endometrium bear no resemblance whatever to the structural modifications of menstruation. All periodical discharges of blood from the uterus during pregnancy are, accordingly, due to some pathological condition of the cervix, decidua, chorion, or placenta.

While pregnancy creates no new property (Pajot), the irritability, contractility, and retractility of the uterine musculature are very greatly augmented. These modifications will be discussed in connection with the diagnosis of pregnancy and the physiology of labor.

Behavior of the Cervix Uteri during Pregnancy.

Conflicting views as to the changes which occur in the cervix uteri during pregnancy and labor have been urged from the latter part of the eighteenth century up to the present day. Within the last fifteen years investigations have assumed a more exact character, and positive opinions are expressed with a greater degree of diffidence as the result, more particularly, of the anatomical researches of Braune and the numerous studies of Bandl. The literature of the subject is so enormous that it is only possible, in the space at our command, to allude to a few of the more important monographs in order to sketch the general outlines of our present knowledge upon this important topic.

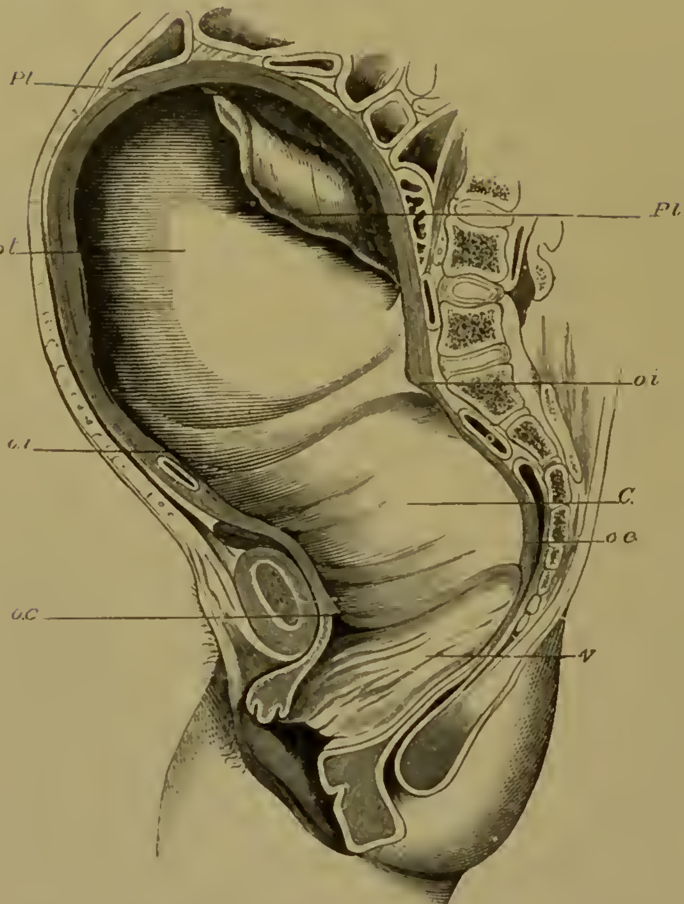
The apparent shortening and ultimate partial or complete disappearance of the vaginal portion of the cervix during pregnancy and labor are such sensible and constant phenomena that their occurrence is not questioned. The causation of the phenomena, however, has been productive of almost infinite controversy—a fact which justifies the conviction that the problem remains unsolved.

Old Theory.—Roederer (1753) and Stein, Sr., his pupil, observed and described clearly and distinctly the apparent shortening and ultimate partial or complete disappearance of the vaginal portion during pregnancy and labor. They promulgated the dogma, explanatory of the phenomena, that as pregnancy advances the cervical canal is dilated from above downward, and is greatly diminished in length in consequence of its being gradually drawn up so as to form part of the general uterine cavity, so that in the latter months only a small vaginal segment remains and the presenting part approaches the os externum. Levret, Baudelocque, and Velpeau taught this doctrine.

Modern Theory.—Certain of the older anatomists—R. de Graaf (1671), Verheyen (1710), and Weitbrecht (1750)—advocated the belief that the cervix uteri persisted in an unchanged condition until the end of pregnancy. Stoltz (1826), probably influenced by the teachings of the older anatomists, opposed the doctrine of Roederer and Stein, Sr., and asserted that the shortening and ultimate partial or complete disappearance of the cervix were only apparent, not actual, and depended upon a fusiform dilatation of the cervical canal, with the approximation of the external and internal ora. This theory, with slight modifications, has been upheld by Kilian (1839), Birnbaum (1841), Boivin, Scanzoni, Cazeaux, Dubois, Depaul, Duncan (1859–63), Taylor (1862), Holst (1865), Spiegelberg (1865), Peter Mueller (1868), Lott (1872), Lusk (1873), Chantreuil, Arthur Farre, Pajot, and others.

In the midst of this confusion of opinions Wilhelm Braune (1872) published his memorable monograph, *The Position of the Uterus and Fœtus at the End of Pregnancy.* The monograph was illustrated by plates made from plane frozen sections of the body of a woman thirty-five years old who died at the commencement of labor. Braune describes the internal os as situated above the inlet, and noticeable from the lumen of a large vein with a smaller one beside it, the only veins which were found patent in the walls of the uterus. "In the empty cavity of the uterus the internal os appeared as a freely-projecting semicircle, 4 cm. above the symphysis and 2 cm. above the promontory of the sacrum. The external os, which was completely dilated, appeared as a small projection." The dimensions of the cervix at the end of pregnancy, according to Braune, are—length of anterior wall of the cervical canal, 11 cm.; of the posterior wall, 10 cm.; circumference, 30 cm.; average thickness of the wall, 5 cm.; capacity 165 cm. (Lahs).

FIG. 199.



Section of Genital Canal after Removal of Child, showing the canalization of the cervix and the canal of Braune (Braune): *Pl.*, Placenta; *o.t.*, tubal orifice; *o.i.*, os internum; *C.*, cervix; *o.e.*, os externum; *v.*, vagina.

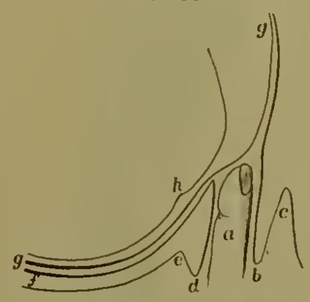
Bandl[1] (1875–76) published two remarkable monographs in general confirmation of the old theory, and in sharp contrast with the doctrine of P. Mueller[2]—a paradigm of the theory of Stoltz. Mueller asserted from the examinations and measurements of one hundred pregnant women that the cervix—irrespective of the position of the presenting part, whether above or below the pelvic inlet—remained in an unchanged condition until the end of pregnancy, and in many cases even during the beginning of labor. "The finger after passing the os externum must traverse a shorter (minimum, ¾ inch) or a longer (maximum, 1¼ inches) distance before arriving at the membranes. At the place at which the membranes are touched a sphincter muscle reacts

[1] *Ueber die Rupture der Gebärmutter*, Wien, 1875; *Ueber das Verhalten des Uterus und Cervix in der Schwangerschaft und Während der Geburt.*, Stuttgart, 1876.

[2] *Untersuchungen über die Verkürzung der Vaginal Portion in den letzten Monaten der Gravidität*, Würzburg, 1868.

as a boundary-line, and if the finger is introduced still higher the walls of the uterus are found relaxed, and absolutely no trace of an internal os can be found." The cervix of Müller, accordingly, is a little thin-walled tube, 2–3 cm. in length, bounded below by the os externum, above by a constriction termed by Carl Braun in 1857 the *isthmus*, the *internal os* by Müller, but more generally known as the *ring of Müller*. Bandl called attention to the facts that the cervix of Müller did not correspond with the virgin cervix of Luschka and Henle, which has a length of 3.5 cm. and a proportionate volume, and that it was inconceivable that this little thin-walled, nipple-like process could be so distended as to receive the head of the child and still be capable of functional activity, as shown in Braune's plate. Bandl's theory, briefly stated, was that at a variable period prior to labor —six or eight weeks—the presenting part or segment of the egg presses upon the internal os of Braune, and a dimple is produced. By degrees the dimple grows larger, the internal os is dilated, the presenting part or segment of the egg descends into the pelvis, while the softened muscular elements of the cervix and the upper portion of the vagina are transferred to the lower uterine segment; the decidua covering the lower segment of the egg cannot keep pace with the growth of the lower uterine segment, is lacerated, and the egg comes into contact with the lower segment of the uterus deprived in part of its epithelial covering. The ring of Müller is seen at the bottom of the lower uterine segment as a displaceable ring of mucous membrane —an *artefact* of nature, as Fritsch terms it, without sphincter functions.

Fig. 200.



Vaginal Portion of a Primipara, with head deep down in the pelvis (Müller): *b*, posterior lip; *c*, posterior fornix; *d*, anterior lip; *e*, anterior fornix; *g*, membranes; *h*, head.

In a median sagittal section of the uterus at term three distinct portions are recognized: 1, corpus uteri; 2, lower uterine segment; 3, mucous membrane. 1. The corpus uteri is differentiated from the lower uterine segment by the thickness of its walls, the arrangement of its muscular elements in accord with Luschka's investigations, noticeably firmer consistence, the decidua large in amount and firmly adherent to the mucosa. 2. The lower uterine segment is more or less sensible in the cadaver according as the egg or presenting part is more or less descended into the pelvic cavity, and according as it has exerted its influence for a longer or shorter period upon the already-formed lower uterine segment. It is differentiated from the corpus uteri by the thinness of its walls, the arrangement of its muscular elements, remarkably softer consistence, the decidua small in amount and loosely adhe-

Fig. 201.

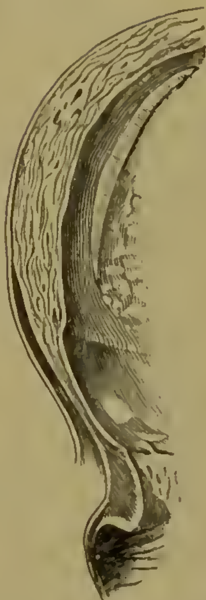


Fig. 202.

Fig. 204.

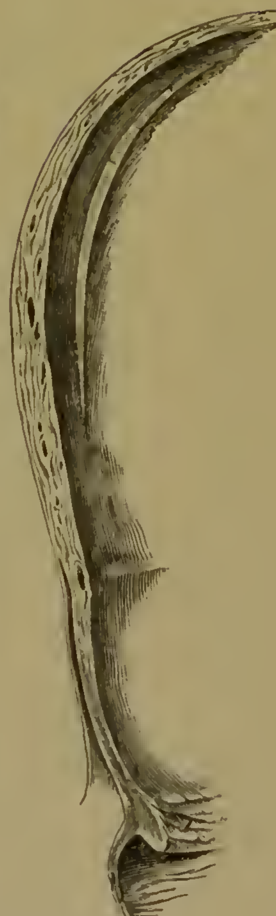
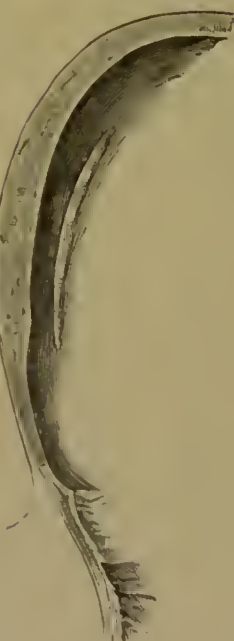


Fig. 203.



Median Sagittal Sections of the Uterus at Term (Braune).

rent. 3. The mucous membrane of the cervix has distinct boundaries above and below, and remains intact for the greater part until term. Bandl's[1] views have since undergone important modifications, especially

[1] *Vortrag. a. d. Münchener Naturforscherrers*, 1877; *Arch. f. Gyn.*, Bd. xii.; *Centralb. f. Gyn.*, 1877, p. 177; *Vortr. a. d. Naturforschervers in Baden-Baden*, 1879; *Arch. f. Gyn.*, Bd. xv.

with reference to the cervical mucosa, as the result of the microscopical investigations of Küstner and Marchand. His recent utterances are to the effect that in first labors the mucous membrane of the dilated portion of the cervix—the lower uterine segment—becomes torn or stripped off, and subsequently a new membrane is formed upon the denuded surface not distinguishable from that of the corpus, which in future pregnancies is capable of forming a decidua. The differentiation between corpus and cervix—lower uterine segment—is accordingly marked by the muscular wedge, vein, peritoneal insertion, and entrance of arteries, as illustrated in Braune's plate, but not by any change in the mucous membrane. The lower uterine segment is the neck of the uterus, and the former term is superfluous.

The ennunciation of Bandl's views has been followed by a lively controversy, which seems to have degenerated into a polemic between Berlin and Vienna. Schroeder designated the internal os of Braune—erroneously termed the ring of Bandl—the contraction-ring, and regarded the lower uterine segment as derived from the corpus uteri. Thus, Hofmeier[1] draws the following conclusions respecting the anatomical and physiological relations of the lower uterine segment:

1. The cervix, characterized by its anatomical structure and mucous membrane, remains intact as a closed or almost closed canal until the beginning of labor. Slight appearances of dilatation in its upper portion are always conditioned upon antecedent uterine contractions.

2. The "lower uterine segment" forms by its anatomical structure and its mucous membrane a well-characterized portion of the uterine body, and differs essentially in both particulars from the cervix of the pregnant as well as of the puerperal uterus. It differs, however, not immaterially, in gross appearance and on minute inspection, from the remaining portion of the uterus, and on this account well deserves a distinct designation.

3. The physiological behavior of the lower uterine segment during labor is essentially passive as opposed to the remaining portion of the uterus, which is sharply contrasted with it by contractions. Since this difference is pronounced and especially palpable only after lively uterine contractions, and since it is apparent as a ring upon the introduction of the hand within the uterine cavity, as well as by external palpation, the designation of this boundary as "contraction-ring" seems to correspond to the actual relations.

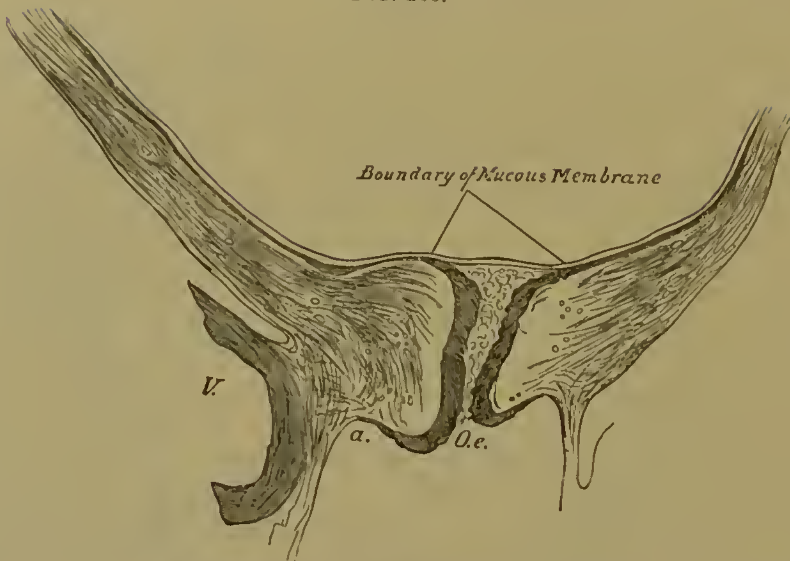
An important contribution to this vexed question has been added by Bayer in the monograph to which allusion has already been made.

Bayer's conclusions are:

1. The mucous membrane of the lower uterine segment produces a

[1] Schroeder: *Der Schwangere und Kreissende Uterus*, Bonn, 1886; *Das untere Uterinsegment in Anatomischer und Physiologischer Beziehung*, p. 70.

Fig. 205.



Gravid Uterus, Tenth Month (Hofmeier): V. vesica; O.e, os externum; a, anterior vaginal fornix.

true decidua, which passes gradually into the mucous membrane of the cervix. This decidua is distinguished by its extraordinary thinness and the longitudinal stretching of its meshes in the ampullary stratum. Genuine cervical mucous membrane extends up the posterior wall of the lower uterine segment to a variable distance. It is impossible to distinguish the site of the internal os by any differentiation of the mucous membrane.

2. It would be better to limit the use of the term "internal os" to the non-pregnant organ or to the uterus in the early months of pregnancy, when the cervix is intact and the mucous-membrane boundary distinct—in a word, to the period during which an internal os really does exist.

3. The perfectly-developed lower uterine segment of the gravid uterus corresponds to the supravaginal portion of the cervix of the virgin organ, from the internal os downward.

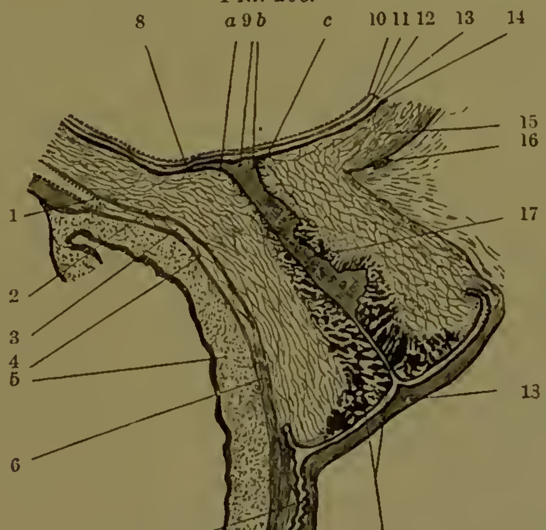
While the object of this note is to present in an impartial manner the most recent views, and not to enter into their critical discussion, still it may be permitted to say, in passing, that the weight of evidence, as collected from internal sources—the nature and amount of material as well as the methods of investigation—seems to us to be very much in favor of Bandl's modified theory. Perhaps it would be as well to accept for the time being a sort of compromise definition, like that of Bayer,[1] for example: "The lower uterine segment is a transient appearance, the formation of which commences in the second half of preg-

[1] *Resultate über das untere Segment., loc. cit.*, p. 398.

nancy, reaches its highest development during labor, and gradually disappears during the puerperium. From a clinical point of view the conception is perfectly definite: it is that portion of the uterus which in normal cases at term envelops the presenting part completely or almost completely. During labor it is especially thinned out, distended, paralyzed, while the thick, contractile muscle-mass of the corpus lies above. The *ensemble* of the phenomena of contraction, with their expulsive effect upon the uterine contents, occur above it, while in it only the appearances of distension during labor and of relaxation afterward are apparent."

While the changes in connection with the formation of the lower uterine segment are usually demonstrable during life and immediately

Fig. 206.



Section through the Cervix Uteri and a portion of the Bladder of a Pregnant Woman, magnified (Waldeyer): 1, peritoneum; 2, reduplication of the connective tissue; 3, cervico-vesical space; 4, connective tissue; 5, bladder; 6, connective tissue between vagina and bladder; 7, lumen of the vagina; 8, from *a* to *b*, and from *b* to *c*, the boundary-line of the cervix; 9, internal os; 10, amnion epithelium; 11, amnion; 12, intermediate layer; 13, chorion; 14, cellular layer and uterine mucosa; 15, muscul. uteri; 16, vein; 17, cervical mucosa; 18, vagina; 19, cervical glands.

after death, as in Chiari's[1] recent drawings, still it must be admitted that in certain cases these alterations are so slightly developed as to escape careful observation. Thus, Waldeyer[2] was unable to find any trace of Schroeder's contraction-ring or of the lower uterine segment in the frozen section of a woman dying within a few days of term; and he expresses the opinion that the cervix persisted in a relatively unchanged condition throughout the pregnancy.

[1] *Ueber die Topographischen Verhältnisse des Genitales einer Inter Partum verstorbenen Primipara*, Wien, 1885.

[2] *Loc. cit.*, p. 28.

The Adnexa.

The round ligaments grow in length to a degree in correspondence with the ascent of the uterus, and become fourfold thicker. The increase in volume is due chiefly to hypertrophic and hyperplastic changes in the non-striated muscular elements of the upper third, and in the voluntary muscular fibres derived from the deep abdominal muscles for the lower two-thirds. On account of the relatively greater development of the posterior uterine wall, the origin of these ligaments is apparently moved forward to a point at the junction of the anterior fifth with the posterior four-fifths of the antero-posterior diameter. Their course at term is from the navel obliquely downward and outward to the inguinal ring. Owing to the axial rotation of the uterus, the left round ligament is especially prominent. The utero-sacral ligaments—the uterine retractors (Luschka)—are notably developed. The musculature of the uterine ends of the tubes undergoes extraordinary evolution, according to the researches of Bayer. The mucous membrane loses its vibratile cilia, and the enlarged lumen is filled with a yellowish-white viscous fluid containing epithelial débris and fat-globules (Robin). At term the tubes seem to originate no longer in the angles of the uterus, but correspond to the middle third of the lateral surfaces. The structural alterations in the ovarian ligaments correspond in general with those in the muscular substance of the tubes. The ovaries increase in volume twofold (Jacquemier), chiefly as the result of the development of the corpus luteum. The ovaries with their ligaments and the tubes are drawn nearer to the body of the uterus and assume a vertical direction.

The pelvic peritoneum covering the uterus is thickened, and grows with the increase of uterine volume until it envelops the supravaginal portions of that viscus. The broad ligaments, sharing in the same changes, are lifted up along with the uterus into the abdominal cavity, so that they assume the general direction of the round ligaments. The connective tissue of the parametrium is augmented in quantity, and becomes more succulent, especially during the last weeks of gestation. Relatively large quantities of adipose tissue are deposited in the peripheral fatty layer. J. Veit asserts that the adipose layer of the pelvic connective tissue disappears entirely in pregnancy under the influence of the serous infiltration.[1] The blood-vessels and lymphatics undergo remarkable development.

The round ligaments, ovaries, and tubes can be traced under favorable conditions by abdominal palpation. The round ligaments, utero-sacral ligaments, and, to a less degree, the broad ligaments, perform

[1] Hoffmann: *Zeitschr. f. Geb. u. Gyn.*, Bd. i. p. 146; Veit: *Die Anatomie des Beckens*, Stuttgart, 1887, p. 5.

important functions as auxiliary powers during labor. The structural changes in the pelvic connective tissue are of especial interest with respect to the process of puerperal septic infection.

The Vagina.

Hypertrophic and hyperplastic changes take place in all the morphological constituents of the vagina, analogous in kind, but less in degree, to those in the uterine parietes. The vagina increases in length, and its capacity is augmented by eccentric hypertrophy as well as by the disappearance of the submucous adipose tissue. The venous plexuses encircling the organ are greatly developed. As the result of arterial hyperæmia and passive congestion and the actual increase in the size and number of the vessels, the mucous membrane from the os externum to the genital fissure acquires a bluish-red hue, which has been compared to the color of wine-lees. The thickened, softened, succulent mucous membrane, exceeding in its growth the limits of the eccentric hypertrophy, is thrown up into folds, and frequently causes a protrusion of the anterior vaginal wall into the vulvar canal as a violet-colored swelling, increased by the corpus cavernosum vestibuli. On account of the hypertrophy of the papillary body the finger often detects granular elevations resembling the morbid condition of vaginitis granulosa. The secretions are increased in quantity, become yellowish-white, and contain, besides epithelial cells and pus-corpuscles, large numbers of a species of infusoria (Trichomonas vaginalis), as well as non-pathogenic bacteria. The vaginal portion, usually situated to the left of the median line to a variable extent, seems shortened on account of the swelling of the mucous membrane and the ascent of the uterus. The position of the vagina varies with the position of the uterus.

The vulva shares in the general growth of the pelvic genitalia. The labia majora and minora increase in size, the veins become varicose, secretions are more profuse; the genital fissure gapes in multiparæ, while it appears smaller and retracted in primiparæ.

The Pelvic Articulations.

Luschka[1] has demonstrated that the sacro-iliac and pubic articulations are true joints, and not amphiarthrodia. This condition is in analogy with the character of these joints in the domestic animals. Strauss and Müller have shown that in these animals the mobility of the pelvic joints has an important function during labor. Lenoir found that in 22 pregnant women between the ages of eighteen and thirty-five years the movements at the sacro-iliac and pubic joints were perfectly evident. If the finger be introduced into the vagina and pressed

[1] *Die Anatomie des Menschlichen Beckens*, Tübingen, 1864.

against the symphysis while the pregnant woman is walking, the elevation of the ramus upon the side of the extremity in motion can be distinctly recognized (Budin). Zaglass described a certain degree of movement in the sacro-iliac joint in the non-pregnant woman. Matthews Duncan has pointed out the exaggeration of this oscillatory movement of the sacrum during pregnancy and parturition. The mobility of the sacro-coccygeal joint is also increased. These alterations in the pelvic articulations occur as the result of elongation of the ligaments and serous infiltration, and are most pronounced during the last weeks of pregnancy and during labor.

The Mammary Glands.

The changes in the mammary glands during pregnancy relate to size, structure, consistence, and function. The increase in the volume of the breasts, frequently noticeable as early as the second month, is progressive, and depends upon hypertrophic and hyperplastic changes in the glandular elements, the deposition of large quantities of fat, and the proliferation of connective tissue between the lobes.

The mammary gland of the embryo, with its simple acini and long excretory ducts, resembles the sebaceous gland in structure. At puberty these lobules branch and increase in size, but the organ reaches complete evolution for the first time during pregnancy. The development of the gland occurs from the periphery toward the centre, and does not affect the organ symmetrically. On palpation it is usually possible to feel irregular nodules and knotty cords, especially in the periphery. The sensibility of the breasts is augmented, and shooting pains, radiating in the direction of the axillæ, are not uncommon. The superficial veins become larger and more distinct, and striæ similar to those on the surface of the abdomen are found in cases of excessive distension of the cutis. The areolæ increase in size, pigmentation is augmented, and the mammillary tubercles are developed. The nipples grow larger, more erectile, and more sensitive. Upon pressure a few drops of colostrum exude.

The Neighboring Organs.

The growth and development of the uterus entail disturbances upon the neighboring organs—in part due to hyperæmia, in part the result of mechanical pressure.

The bladder becomes more irritable. Frequent micturition, incontinence, and vesical tenesmus are frequent symptoms during the early months. These phenomena are caused by the pressure of the gravid uterus—limiting the capacity of the bladder in some cases—the stretching of the neck of the bladder when the uterus ascends into the cavity of the abdomen, and the congestion of the vesical mucous membrane.

During the last weeks of gestation the urethra is sometimes compressed by the presenting part, and retention or the incontinence of retention not infrequently results.

Constipation is apparently the normal condition of the pregnant woman. In many cases this habit has been established prior to gestation. In all cases, however, pressure of the gravid uterus upon the sigmoid flexure, restricted intestinal peristalsis, and the limited action of the abdominal parietes are important etiological factors.

Œdema and varices of the lower extremities, the external genitalia, and the rectum arise from increased intra-abdominal pressure, or, in the early months, from the slowing of the venous current conditioned upon the dilatation of the pelvic veins and the increase in the intra-abdominal pressure. Neuralgias of the lower extremities and abdominal surface are frequently symptomatic of pressure upon the nerve-trunks from the lumbar and sacral plexuses.

The Abdominal Wall.

Important changes occur in the musculature of the abdominal walls during pregnancy. A physiological diastasis of the recti is produced during the last three months in the very large majority of cases. Cruveilhier noticed this separation of the two longitudinal muscular bundles at term, and has found it to measure several centimeters.[1] The anatomical cause consists in the stretching of the transversalis, internal and external oblique muscles by the heightened intra-abdominal pressure and the pressure of the growing uterus. The latter factor is directly operative, especially when the woman is erect. Schroeder has found the distance from the ensiform process to the pubic joint 47 cm. when the woman was standing up, and only 40 cm. when she was lying down. The tension, concentrated upon the linea alba, is transferred to the aponeurotic sheaths of the recti, a centripetal attraction is developed, and the inner edges of the muscles separate.

The elasticity of the muscles of the abdominal wall is lessened, and in cases of great distension actual loss of muscle tonus and changes due to pressure-atrophy ensue. The transversalis, external and internal oblique muscles suffer chiefly, while the recti, on account of their long, narrow, thick character, are seldom involved, except in case of extreme distension, as in multiple pregnancy or hydramnion.

The diastasis of the recti becomes very palpable upon the expression of the placenta by the Dublin method. In the operation of laparotomy for large tumors only slight traces of the musculature of the abdominal walls are found to remain, and the linea alba presents the line of greatest tension. Upon the examination of the abdomens of multiparæ about

[1] Prochownick: "Die Diastase der Bauchmuskeln im Wochenbett," *Arch. f. Gyn.*, xxvii. Bd. iii. p. 424.

the eighth month—especially in cases of pregnancies succeeding each other at brief intervals—the loss of elasticity, muscle tonus, and the changes due to pressure-atrophy are very plain. The recti are usually well preserved, and stand out in sharp contour from the relaxed lateral aspects of the abdomen. The ileo-costal portions of the quadratus lumborum—the rectus abdominis posticus of Luschka—are also clearly outlined.

Under favorable conditions the diastasis of the recti disappears, and the other muscles regain their normal tonus within the first two or three weeks of the puerperium. But in cases of original defective development of the abdominal muscles, excessive abdominal distension during gestation, pregnancies succeeding each other at brief intervals, or insufficient care during the puerperium, the diastasis and changes due to pressure-atrophy may persist throughout life, with all their concomitant evils.

The practical import of the changes thus briefly mentioned is obvious. They explain very many cases of the constipation incident to pregnancy. It is a pretty well-established clinical fact that indications for the forceps operation occur more frequently in the United States than on the continent of Europe. This is especially true of the so-called low-forceps operation. The powers of labor seem to be relatively insufficient on account of partial or complete failure of the contractions of the abdominal muscles. This failure may be assumed to be due in part to defective development, in part to the changes incident to pregnancy. Then a strong *a-priori* argument in favor of the use of the obstetric binder during the puerperium may be deduced from the consideration of these changes—an argument greatly strengthened by Prochownick's[1] observations.

The insertions of the abdominal muscles—the internal oblique and the transversalis in particular—into the lower borders of the cartilages of the lower ribs are rendered tense by the growth of the uterus, giving origin at times to considerable pain. This pain is usually most severe on the right side, on account of the dextro-lateral version of the pregnant womb. The symptom is observed most frequently in elderly primiparæ between the eighth and ninth months.

II. General Changes in the Maternal Organism.

The general changes in the maternal organism, frequently obscure as to genesis, depend largely upon the quantitative and qualitative alterations of the blood and the functional modifications of the nervous system, which, in turn, are greatly influenced by the developing germ-

[1] See also Marie Schlee: "Ueber der Dehnung der Bauchwand Während der Schwangerschaft," *Zeitschr. f. Geb. u. Gyn.*, Bd. xiii. p. 1.

inal mass in the uterus and the blood-changes. The consideration of these changes constitutes in a large degree a study of the process of nutrition.

While great, and sometimes essential, differences of opinion exist with reference to many alleged facts and the interpretations of such facts, as in other branches of medical science, still, as remarked by Michael Foster, "this agonosphere is merely the envelope of a solid nucleus of acquired truth, which year by year grows larger at the expense of its more fluid and gaseous wrappings." Apart from the utility of the study of the general changes in the maternal organism in the diagnosis, the management, and the comprehension of the morbid conditions of pregnancy, much light is thrown upon many obscure problems in general pathology.

The Blood, Circulatory Apparatus, and Blood-glandular System.

The alterations in the blood affect its quantity and quality. The physiological necessity for an increase in the total blood-mass is rendered evident by a number of *a-priori* considerations. The normal quantity of blood would be totally inadequate to supply the increased demand for nutritive material created by the fœtus and its envelopes, the uterus, and the enormously increased circulatory area, without the production of serious anæmia in other organs. Gassner has demonstrated that the increase in body-weight during the last three months of pregnancy is greatly above that accounted for by the uterus and its contents. Of course the blood must participate in this gain. Finally, Spiegelberg[1] and Gescheidlen have determined by experiment that in bitches the total quantity of blood is increased during the second half of pregnancy. We may, accordingly, assume that the total blood-mass in the normal pregnant woman is augmented, especially during the second half of gestation.

The qualitative changes in the blood relate to its water, albumen, corpuscles, fibrin, and iron. The researches of Andral,[2] Gavarret,[2] Delafond,[2] Becquerel,[3] Rodier,[3] Regnauld, and Nasse,[4] indicate that there is an absolute increase in the white corpuscles, fibrin, and water, and an absolute diminution in the red corpuscles and albumen. Spiegelberg and Gescheidlen[5] conclude, from their investigations upon bitches—

1. The total blood-mass increases during pregnancy, but only during the second half.

[1] The modified Welker method (carbonic oxide-hæmoglobin).
[2] *Annales de Chymie et de Physique*, Juillet, 1842.
[3] "Recherches sur la Composition du Sang," *Gaz. méd. de Paris*, 1844, p. 757.
[4] *Arch. f. Gyn.*, Bd. x. p. 338.
[5] *Ibid.*, Bd. iv. p. 112.

2. The amount of hæmoglobin varies within limits which depend upon the nutrition of the animal.

3. The increase in water, if it occur at all, is insignificant.

Nasse, from experiments on bitches before, during, and after pregnancy, has recently reaffirmed his original proposition, that the amount of hæmoglobin is diminished during pregnancy independently of the nutrition of the animal, and that the amount of water is absolutely increased. Ingerslev,[1] counting the red blood-corpuscles, was unable to detect any marked diminution during pregnancy. Fehling[2] finds an augmentation in the amount of hæmoglobin and an increase of the number of red corpuscles in the blood of the pregnant woman. The most recent contribution to our knowledge upon this subject is contained in the researches of Meyer.[3] Meyer concludes, from the examination of the blood of pregnant and non-pregnant women with v. Fleischl's hæmometer, that—

1. The number of red corpuscles and the amount of hæmoglobin are diminished during pregnancy.

2. After labor the number of red corpuscles and the amount of hæmoglobin rapidly increase.

The weight of evidence, upon the whole, is very much in favor of the view that the blood of the pregnant woman is normally in a state of serous plethora.[4] Individual variations, however, are numerous and extreme. Favorable environment and sufficient food may induce a state of true polyæmia, while bad hygienic surroundings and inadequate nutriment more frequently reduce the blood to a condition of chlorosis or hydræmia. The explanation of the diminution in the albumen and hæmoglobin is found in the surrender of nutritive material to the fœtus, while the increase in the white corpuscles and fibrin may be ascribed to the extraordinary tissue-changes in the uterus, and the consequent growth of the lumbar and pelvic lymphatic glands. Virchow describes the increase in the number of the white corpuscles as a physiological leucocytosis.

Larcher[5] in 1828 directed attention to temporary hypertrophy of the heart as a constant physiological phenomenon of pregnancy. He asserted that the hypertrophy was restricted to the walls of the left ventricle, which increased from one-fourth to one-third in thickness during the latter months of gestation. The cardiac enlargement, believed to be the cause of the præcordial murmur so often heard during pregnancy, was the consequence of the peripheral resistance opposed by the gravid uterus. Blot concludes from the examination of the hearts of twenty

[1] *Centralb. f. Gyn.*, 1879, p. 635. [2] *Arch. f. Gyn.*, Bd. xxviii. Heft 3, p. 454.

[3] "Untersuchungen über die Veränderungen des Blutes in der Schwangerschaft," *Arch. f. Gyn.*, Bd. xxxi. Heft 1, p. 159.

[4] Kiwisch: *Die Geburtskunde*, p. 285. [5] *Gazette des Hôp.*, 1857, No. 44.

puerperal women that the left ventricle gains about one-fifth in weight. Ducrest confirms Larcher's observation from the measurement of the thickness of the cardiac walls in one hundred women dying in pregnancy or soon after labor. Joulin, De Cristoforis, Spiegelberg, Duroziez,[1] and Robert Barnes have added corroboratory testimony.

Then, too, we are in possession of numerous facts which go far to prove the physiological necessity of eccentric hypertrophy of the left ventricle. The augmentation of the total blood-mass, the intercalation of the placental circulation between the uterine arteries and the veins, the increased intra-abdominal pressure rather than the pressure of the gravid womb,—all imply increased cardiac labor, and demand for their explanation either increased force or frequency of the heart's action. Now, it is known that the heart's action during pregnancy increases[2] in frequency only slightly, if at all,[3] while Marey, Mahomed, Macdonald, and others have demonstrated that there is a considerable increase in arterial tension.

All observers agree as to the fact of increase in the area of cardiac dulness.

On the other hand, Gerhardt[4] asserts that no cardiac hypertrophy occurs during gestation, and the increased area of cardiac dulness is explained by the change in the position of this viscus from the distension of the abdominal cavity. Löhlein,[5] citing Friedreich, Virchow, and Dusch, supports Gerhardt's position. Curbelo's[6] conclusions are opposed to the results of the French observers.

Finally, Létulle[7] claims that cardiac hypertrophy during pregnancy is inconstant, but that dilatation of the cavities always takes place.

Upon the whole, the weight of probable evidence is very decidedly in favor of the view that during pregnancy a slight temporary hypertrophy of the left ventricle is a constant and a physiological phenomenon.

De Cristoforis,[8] in the explanation of the cardiac hypertrophy, œdema, and varices of the lower extremities incident to pregnancy, describes a mechanical inferior venous hyperæmia from the pressure of the pregnant uterus on the iliac veins, and a superior arterial hyperæmia from pressure on the aorta at its bifurcation. While no doubt exists as to the fact of hydraulic derangements in the circulation resulting in some degree of arterial hyperæmia in the parts above the diaphragm and in

[1] *Gazette des Hôp.*, 1868.

[2] *Archives générales de Médecine.* According to Hémey, the heart of the normal pregnant woman beats seventy-five times per minute.

[3] Pierre Louge: *Le Pouls puerpéral physiologique*, Paris, 1886, p. 38. According to Louge, from seventy-two to seventy-five times.

[4] *De situ et magnit. cordis gravid.*, Jena, 1862.

[5] *Zeitsch. f. Geburt. u. Frauenkrank.*, 1876, p. 482.

[6] *Dis. Inaug.*, Berlin, 1879.

[7] *Archives générales de Médecine*, 1881.

[8] *Annali Universali di Medicina*, 1867.

venous hyperæmia of the parts below the plane of the vaginal junction, the interpretation of the phenomena made by De Cristoforis is totally inadequate, for a number of reasons.

Increased vascular tension, as pointed out by Robert Barnes, begins early in pregnancy, before the uterus has attained a size sufficient to exert any considerable pressure upon the aorta or iliac veins.

Moreover, Lahs[1] has shown that the gravid uterus has the mechanical value of a sac with relaxed walls filled with fluid, and possesses the same pressure-effect as fluid free in the abdominal cavity, whose surface corresponds in altitude with the liquor amnii. The pressure upon the vena cava and the aorta is accordingly represented by the product of the area of surface of these vessels in contact with the uterine wall, by the altitude of the supernatant column of liquor amnii, the body of the fœtus being of inconsiderable moment.

The difference between the pressure of the gravid uterus—or of fluid free in the abdominal cavity under the condition specified—and the usual intra-abdominal pressure in the non-gravid state is slight. The normal abdominal contents in the non-pregnant state—the intestines, the omentum with its greater or less masses of fat, the mesentery—in the absence of any accumulation of gas in the intestinal canal possess nearly the same specific gravity as the uterus and its contents. Besides the nearly identical specific gravity, the contents of the abdomen, on account of their capability of configuration, possess almost the same mechanical value as fluid. In other words, the weight superimposed upon the pelvic inlet and the vessels there situated at term is nearly the same as in the non-pregnant state, and the mode of expression of this weight in view of its fluid character is the same in the former as in the latter case. Now, since it is perfectly well known that in the non-pregnant state the blood-currents in the vessels mentioned are not disturbed, why should they be interfered with during pregnancy?

The cause of mechanical interference with the blood-currents does not lie in the weight of the uterus and its contents at all. Apart from the compression exerted by the presenting part engaged within the pelvic inlet, the cause lies in the increased pressure upon the blood-vessels by uterine contractions, and the general increase of intra-abdominal pressure which keeps equal pace with the augmentation in uterine volume. This intra-abdominal pressure is obviously greater when the woman is erect and working than when she is recumbent and idle. On this account we find the most extensive varices, other things being equal, in women subjected to severe bodily exertion during gestation, although it must be admitted that individual differences in the tonus of the blood-vessel walls constitute an important factor in these changes. The inferior vena cava is subjected to this increase in intra-abdominal

[1] *Die Theorie der Geburt.*, Bonn, 1877, pp. 5–7.

pressure for nearly its entire length, and the return of venous blood from the lower extremities is hindered to a proportionate degree. The aorta, of course, does not remain unaffected by this pressure.

In the light of Lahs' demonstrations it is perfectly clear that the disappearance of the so-called mechanical œdema of the lower extremities upon the assumption of the horizontal position—a familiar clinical fact—is not due to the removal of the pressure of the gravid uterus from the pelvic inlet, but is caused by the reduction of intra-abdominal pressure by rest in the dorsal decubitus.

The possible applications of this doctrine of increased intra-abdominal pressure as the cause of many of the so-called mechanical disorders of pregnancy are numerous and important.

The hypertrophy of the thyroid gland, and consequent fulness of the neck, apart from any local disease or endemic influence during pregnancy, is such a sensible and frequent phenomenon that the ancients recognized its occurrence. Thus, we see the Venus of Milo, a girl on the verge of womanhood, with a slender, delicate throat, due to the rudimentary state of the thyroid, in strong contrast with the Venus Callipyge, a woman in magnificent maturity, undoubtedly parous, with a broad, full throat and marked thyroid development. The Latins, scarcely less critical than the Greeks, observed the same appearance. Thus Catullus remarks in the "Epithalamium:"[1]

> "Non illam nutrix oriente revisens
> Hesterno poterit collum circumdare filo."

The organ diminishes in size during the puerperium, but remains more voluminous than prior to pregnancy. The enlargement of the thyroid is generally supposed to sustain some relation to the changes in the heart and blood-glandular system incident to pregnancy, the exact nature of which is a matter of speculation.

According to the observations of Birch-Hirschfeld,[2] the spleen increases normally in size and weight. The average weight of the organ at term in the cases examined was 180 grm., as opposed to the normal average weight of 140 grm. in the non-gravid state. This change corresponds with the alterations in the other organs of the blood-glandular system, and is supposed to sustain some important relation to the qualitative changes in the fluids of the circulation.

Rokitansky in 1838, Ducrest and Moreau in 1844, called attention to lamellæ of osseous material, chiefly on the inner surface of the calvarium, external to the dura mater, under the term "puerperal osteophytes." They are situated on the inner surfaces of the frontal and parietal bones, along the furrows of the middle meningeal artery and the sulcus falciformis. Follin and Claude Bernard have observed

[1] Quoted by Robert Barnes.

[2] *Berl. klin. Woch.*, 1878, p. 324.

similar osteophytes on the inner surfaces of the pelvic bones of puerperal women. Occasionally they have been noted on the external surface of the occipital bone. They have been found in rather more than one-half of all the cases examined of women dying after the fifth month; with relative frequency in primiparæ. They are of irregular shape, relatively long, 2–4 mm. in thickness, of reddish-white color in the recent state, and consist chiefly of calcium carbonate, organic matter, and traces of the phosphates. At first it was supposed that these osseous neoplasms were peculiar to pregnancy, but Virchow, Wallmann, and others have observed similar concretions in tuberculosis, chronic hydrocephalus, and syphilis. The ultimate fate of the puerperal osteophytes is unknown. It has been suggested that they represent the excess of ossific material out of which the fœtal skeleton is built up. Robert Barnes thinks they sustain some relation to the preparation of milk and the calcareous changes in the placenta.

Temperature.

The bodily temperature during pregnancy does not differ materially from that in the non-gravid state. According to the observations of Gruber and Frankenhäuser, it is slightly lower during the *evening* than during the *day*. This fact is ascribed to the cooling of the blood in its slow course through the dilated veins of the lower extremities and pelvis during the day, when the woman preserves an erect attitude. When she lies down the mechanical obstacle to the return of the venous blood is largely removed, and this dissipation of heat does not occur.

The Nervous System.

The psychical changes incident to pregnancy are subject to innumerable individual variations. As a rule, emotional susceptibility is greatly increased. The pregnant woman becomes exquisitely irritable in the physiological sense of that term, and readily responds to external stimuli that in the non-gravid state would awaken no response. In a small proportion of cases the woman feels unusually well and takes a more active interest in intellectual pursuits and the ordinary affairs of life. More frequently, however, a degree of despondency, entirely beyond the control of the will, is observed. The cheery, amiable woman is apt to become moody and peevish; sometimes a disagreeable disposition is transformed into a happier state of mind. These changes in mental habitude are measurably dependent upon the degree of the desire for offspring. In certain cases the woman becomes dull, apathetic, and inclined to drowsiness.

Functional disorders of sight, hearing, smell, and taste—amblyopia, hemeralopia, slight deafness, perversions of taste and smell; of the sensory, motor, and vaso-motor nerves—neuralgias, hyperæsthesia, vertigo, syncope, local anæsthesiæ, and pareses—are of infrequent occurrence in the absence of structural changes in the corresponding organs. In the absence of a sufficient cause they may be assumed to be due to the qualitative changes in the blood and to the alterations in the genital organs, giving origin to various reflex effects.

The reflex activity of the spinal cord undergoes augmentation, of which a notable example is morning sickness. As at present informed, it is impossible to say whether or not the amount of nervous tissue—in portions of the body other than the uterus—is increased. Analogy favors the view that incremental changes do occur, but we are not in possession of data sufficient to settle this question.

Respiration.

The tests with the spirometer by Küchenmeister, Fabius, and Wintrich indicate that the vital capacity of the lungs is not diminished during pregnancy. Gerhardt's observations show that the width of the thoracic base is increased, and that the position of the diaphragm is not materially altered, although its downward excursions are restricted and respiration becomes thoracic instead of abdominal. In Waldeyer's plane frozen section the highest point of the diaphragm is on a level with the middle of the eighth thoracic vertebra, while in Braune's[1] section of a woman in the beginning of pregnancy the cordiform tendon corresponds to the lower border of the eighth thoracic vertebra. Dohrn[2] found, by means of the cyrtometer, the antero-posterior diameter of the thorax diminished, while the breadth of the base was increased. Marked diminution in the vital capacity of the lungs was noted in 60 per centum of the women examined—near term—as compared with the results obtained from examination of the same women twelve to fourteen days after delivery.

The frequency of respirations early in pregnancy, and the dyspnœa near term, especially when the woman is the subject of a contracted pelvis or spinal curvature, have led Tarnier, Chantreuil, and others to conclude that both the vital capacity and the thoracic space are diminished. The relief in breathing experienced so commonly after the sinking of the womb and engagement of the presenting part just before labor is an important fact in favor of the view of the French observers.

Andral and Gavarret assert that the exhalation of carbonic acid is augmented during pregnancy, as it is after the cessation of menstruation from other causes.

[1] Tab. ii. A.

[2] *Mon. f. Geburts.*, Bd. xxviii., 1866, p. 457.

The Alimentary Tract.

Nausea, and even retching or vomiting, with the bringing up of some glairy fluid, on first rising from the recumbent posture are phenomena of early pregnancy so nearly constant and so devoid of injurious effects that they are justly regarded as physiological. On account of the time of occurrence the symptom is generally known as the "morning sickness," although it is exceptionally observed only in the afternoon. The "morning sickness," beginning commonly at the second month, sometimes immediately after conception, ceases spontaneously, as a rule, between the third and fourth months. Nausea near term may be physiological from pressure of the fundus, but in the absence of any local cause should be regarded with suspicion as a possible prodrome of uræmia. The symptom is observed with greatest relative frequency in primiparæ. The causation of morning sickness is obscure, but probably consists in some anomaly of innervation. Robert Barnes regards the symptom as the expression of high nervous tension, and the stomach as "the seat of election for the discharge of superfluous nervous energy." Bedford,[1] indeed, insists upon the old observation that in the absence of morning sickness other, more distressing, disorders are present, such as tendency to syncope, aptitude to miscarriage, and the like. The increase in the size of the womb and the qualitative alterations in the blood cannot be invoked as etiological factors, since these changes are of moment only during the latter half of pregnancy, after the disappearance of the symptom. The essential factor in the process of digestion—assimilation—is not changed so long as the nausea remains within physiological limits.

The appetite of the pregnant woman increases even during the period of nausea, and is proverbially whimsical. Its caprices, popularly known as "longings," are dependent in certain cases upon the morning sickness; in other cases, especially in primiparæ, they are assumed or imaginary, in accordance with the traditional belief that they are incident to the condition of pregnancy. Veritable examples of pica—perversion of appetite—although infrequent, are recorded. Thus, depraved longings have been shown for green apples, chalk, pepper-grains (Cazeaux), bits of charred wood (Dubois), and even for human flesh, as "in the case of the woman who, craving her husband's flesh, killed him, and to prolong her enjoyment salted him down."[2]

The secretion of the salivary glands is increased in exceptional cases, and becomes more aqueous.

[1] *Diseases of Women and Children*, p. 551.

[2] Robert Barnes: *System of Obstetric Medicine and Surgery*, Philada., 1885, p. 176.

The Liver.

Tarnier in 1857 concluded, from a series of observations upon women dying during or shortly after labor, that the liver is usually enlarged as the result of a peculiar fatty infiltration. This change he describes in the following words:

"The color of the hepatic tissue is not uniform, its substance being sprinkled with minute yellow spots so numerous as to give it the appearance of granite. The spots also seem to form so many projecting points, of a size varying from that of a pin's head to that of a millet-seed. Sometimes they are disseminated, at others aggregated, forming in the latter case little insular patches, though sometimes the agglomeration is such as to give rise to a yellow spot of an inch or more in diameter. This appearance is not limited to the surface of the liver, but will be found in any section made through the substance of the organ. A microscopic examination of this tissue, made in connection with Dr. Vulpian, revealed the hepatic cells in normal condition, mingled with an abundance of fat-globules."

De Sinéty has noted the same phenomenon in the lower animals, and thinks that the change is physiological—an opinion shared by Robert Barnes and Ewart, who have also observed this infiltration.

According to De Sinéty, the infiltration commences around the intralobular vein and proceeds toward the periphery, the reverse of the order in which pathological fatty infiltration or metamorphosis affects the lobule.

The functional significance of these structural alterations in the liver will be discussed under another topic.

Nutrition.

Pregnancy exercises normally a favorable influence upon nutrition, and the body-weight, apart from fœtal development, increases progressively, even in cases of slight morning sickness, from the beginning to the end of gestation. Gassner[1] has shown that the body-weight increases 2.4 kg. during the eighth lunar month, 1.69 kg. during the ninth, and 1.54 kg. during the tenth. This augmentation in metabolic activity seems to be dependent upon the nutritive energy imparted by the growing ovum, since the same investigator has observed a sudden remarkable diminution in weight (2–3 kg.) in three cases following the death and retention of the fœtus in utero for a period varying from eight to fourteen days.

In general, it may be said that a woman's weight is about one-thir-

[1] "Ueber die Veränderungen des Körpergewichtes bei Schwangeren, Gebärenden und Wöchnerinnen," *M. f. G.*, Bd. xix., 1862.

teenth greater at the end of pregnancy than it was at the commencement.

Of all the tissues in the body, apart from the genitalia, the adipose tissue increases most in bulk during gestation, especially during the second half. The deposits of fat are observed particularly in the mammary glands, the paniculus adiposus of the abdominal parietes, the pudenda, the superficial fascia of the hips and gluteal region, the omentum, and the fatty peripheral layer of the pelvic connective tissue. These changes impart the familiar rotundity to the figure. The store of adipose tissue thus laid away constitutes so much potential energy to be converted by the metabolism of the body in part into milk, in part into the actual energy of heat and mechanical labor.

The Urine.

It is asserted that the kidneys become larger during pregnancy as the result of heightened functional activity.

The urine undergoes quantitative and qualitative changes. The total amount excreted during twenty-four hours is augmented in its aqueous elements in consequence of the alterations in the blood-mass and the high arterial tension. According to Winckel,[1] the daily excretion of urea, sodium chloride, the sulphates, and phosphates is not changed. Chalvet and Barlemont (1870), however, have found an increase in the chlorides and a diminution in the phosphates, sulphates, urea, uric acid, creatin, and creatinin. Lehmann and Donné suggest that the deficiency in these substances is due to their use in the development of the fœtus.

Nauche in 1831 described the formation of an iridescent filmy covering appearing upon the urine of the pregnant woman several hours after its excretion, and being precipitated to the bottom of the vessel on the fifth day. He termed this covering the kyesteinic pellicle, attaching to it diagnostic significance. Elisha Kent Kane, the Arctic explorer, Braxton Hicks, Cazeaux, Scanzoni, and numerous others have observed the same phenomenon in the urine of virgins and of men, and have demonstrated that the so-called kyesteinic pellicle consists chiefly of the ammonio-magnesian phosphates and vibriones, sustaining no necessary relation to pregnancy.

Blot[2] in 1856 found glucose in the urine of one-half of the pregnant women examined, in quantities varying from 0.1–1.2 per centum, and asserted that the quantity stood in direct relation to the activity of the mammary glands. Kirsten[3] confirmed Blot's observation, but referred the glycosuria during lactation to a pathological increase in the glyco-

[1] *Stoffwechsel bei der Geb. und im Wochenbett*, Rostock, 1865.

[2] *Gaz. des Hôp.*, 1856, No. 121.

[3] *M. f. G.*, 1857–59.

genic function of the liver. Brücke[1] in 1858 affirmed that traces of glucose were almost constantly found in normal urine, and that the quantity in the urine of puerperæ was frequently very much increased within physiological limits.

Tarnier, rejecting the notion of a physiological resorption diabetes, ascribes the glycosuria of pregnancy to the hepatic changes already indicated.

Traces of albumen are found in the urine of a small proportion of pregnant women in the absence of demonstrable structural changes in the kidney. In many cases this so-called physiological albuminuria is referable to a catarrhal inflammation of the vesical mucous membrane. Then, too, as pointed out by Leube and Mahomed, albuminuria without tube-casts may occur as the result of passive congestion of the kidneys or increased vascular tension. In view of the grave significance of Bright's disease during pregnancy, the symptom always demands serious attention and calls for frequent examinations of the urine through a considerable period of time. The general condition of the woman must also be attentively observed to determine whether or no there are other symptoms of the existence of grave kidney disease. Pavy has described a condition under the term *cyclic albuminuria*, in which albumen is found at a certain time of the day and not at any other. The albumen appears after rising, attains a maximum within one and a half or two hours, and then declines, completely disappearing when the woman resumes the recumbent posture. This condition is probably dependent upon some change in the blood-vessel walls, and seems to be of no serious import. The condition is also observed in the non-pregnant woman and in the male.

The Skin.

The functional activity of the sebaceous and sweat glands and the hair-follicles is greatly increased during pregnancy. The changes in the mammary glands, belonging to the class of skin-glands, have already been indicated. Robert Barnes is responsible for the observation that "women who had been losing hair when not pregnant found its growth restored during pregnancy, and falling out again after labor."

Among the physiological anomalies, the various deposits of pigment and the formation of striæ or lineæ albicantes are especially worthy of mention. Deposits of pigment are observed around the nipple—the primary and secondary areolæ—along the median line of the abdomen from the pubes to the navel, around the navel—the umbilical areola of Montgomery—sometimes along the median line from the umbilicus to the ensiform process, in the labia majora and nymphæ, and in the

[1] *Sitzungsberichte der Kais. Acad. d. Wissensch.*, Wien, xxviii., xxix., 1858.

face. Irregular pigmentations are occasionally seen involving the entire skin surface of the breasts, as in the Samoyed women, or of the abdomen, as in the case described by Bomare,[1] or of a lower extremity, as in the case referred to by Le Cat.

Patches of pigmentation are often observed on the forehead, root of the nose, and the upper lip, giving origin to the expression, the "mask of gestation." Joulin has seen this appearance particularly in women exposed to the sun and atmospheric influences, as among the peasantry of France. McLane[2] reports a case in which the disfigurement was so great as to compel the woman to remain within her house. These pigmentations vary greatly as regards extent and intensity. They are usually more marked in brunettes than in blondes. They gradually fade away after labor, but seldom completely disappear.

Their causation is obscure. Jeannin[3] suggests the amenorrhœa of pregnancy. Robert Barnes thinks they are trophic in origin, and refers them to a hypothetical transitory hypertrophy of the suprarenal capsule. Laycock regards them as produced (1) from imperfect oxidation of carbon, (2) from imperfect elimination of carbon, and (3) from excess in the production of carbon from highly carbonaceous foods.

A parasitic skin disease, closely allied to pityriasis versicolor, occurs so frequently during pregnancy that it has received from Elsässer the name of *pityriasis gravidarum*. Spiegelberg has observed this disorder most frequently in enfeebled individuals—an observation confirmed by James Nevins Hyde. The efflorescence of this disease resembles certain of the anomalous pigmentary deposits incident to pregnancy. The differential diagnosis, however, is usually easy. Microscopical examination of the superficial scales reveals the characteristic fungi in pityriasis, and the disease disappears under appropriate treatment—*i. e.* the local application of ten grains of veratrin in one ounce of alcohol or thorough washing with the tincture of green soap.

The skin of the abdominal walls, stretched by the growing uterine tumor, undergoes hypertrophy and the adipose tissue of the superficial fascia is augmented. The umbilical depression is diminished at the end of the fifth month, and is on the same plane with the surrounding integument at the end of the sixth month. During the last four months it is everted to a variable extent. In the very large majority of cases the growth of the abdominal integument does not keep pace with the growth of the uterine tumor; its elasticity is overcome, and pinkish or bluish-red streaks appear. After labor these streaks become white or pearl-colored. Technically, they are known as lineæ albicantes, striæ gravidarum, or the so-called cicatrices of pregnancy. The striæ gravi-

[1] Laycock: *The Nervous Diseases of Women.*

[2] *New York Medical Journal*, May, 1878.

[3] *Gaz. hébdom.*, 1868.

darum,[1] usually appearing during the last three months of pregnancy, are caused by a thinning of all the skin-layers, due to pressure-atrophy, partial obliteration of the lymph-spaces, and to a rearrangement of the connective-tissue elements, which now run parallel to one another. They are found in greatest numbers at the site of the greatest tension of the cutis, in the lower half of the abdomen and to the sides, where the femoral fasciæ are intimately united with the skin.[2] They pursue a course at right angles to the direction of greatest tension, which is transverse. Accordingly, they run parallel to the linea alba. Around the navel they form concentric rings, since the direction of tension at this point is radial and concentric.

The lineæ albicantes are also found in the gluteal regions, anterior, posterior, and inner surfaces of the upper femoral region, and in the cutis covering the mammary glands. Crede has found them absent in 10 per centum of all the cases examined; Hecker, in 6 per centum.

They are not peculiar to pregnancy, but occur in cases of rapid distension of the abdomen from other causes, as ascites, ovarian tumors, and the like. Schultze has observed them in 36 per centum of women who had not borne children.

THE OSSEOUS SYSTEM.

On account of the growth and inclination forward of the pregnant uterus, the centre of gravity tends to fall in front of the pubes, and in order to maintain her equilibrium in the erect posture the woman is obliged to throw her head and shoulders backward. The incurvation of the spine is accordingly increased, while the pelvic inclination is diminished. This change in carriage is especially marked in women of low stature, causing a peculiar strut in their gait not destitute of diagnostic significance.

Delay in the ossification of the callus following a fracture is occasionally observed during pregnancy. Padieu[3] describes an unusually clear case in which the tibia and fibula of one leg were broken nine days after the suppression of menstruation. Union was delayed during the entire period of pregnancy, but began to take place ten days after delivery, and was perfect at the end of one month. Upon the hypothesis that the relation between the delay in union and pregnancy was necessary, and not mere coincidence in point of time, it is not improbable that the lime salts were used up by the fœtus at the expense of the callus.

[1] S. C. Busey: *Trans. Am. Gynæc. Soc.*, vol. iv.

[2] Krause und Felsenreich: "Die Spannungsverhältnisse der Bauchhaut bei Gravidität., *Arch. f. Gyn.*, xv., 1880.

[3] *Journal de Médecine et de Chirurgie pratique*, 1887.

The Diagnosis of Pregnancy.

The signs of pregnancy have been variously classified as the *rational* and *sensible* signs, or as the *presumptive*, the *probable*, and the *certain* signs, or as the *subjective* and *objective* signs. Most systematic writers, however, are in the habit of discussing each symptom in the order in which it appears in point of time. This plan recommends itself for simplicity and for ease of application in practice. The entire duration of pregnancy is divisible into three equal periods, or trimesters, by certain well-defined groups of symptoms. This division is of great convenience in the discussion of the subject, and, at the same time, of practical value in the diagnosis of the time of gestation and the probable duration of the condition.

The importance of as nearly a purely objective diagnosis as the conditions of the concrete case will permit needs no special emphasis at the present day. Fortunately, the objective changes incident to pregnancy are so numerous, occur so early, and many of them are so characteristic that commonly the physician is able to form a positive opinion upon adequate evidence derived exclusively from his own perceptions.

I. First Trimester.

1. Subjective Signs.—*Suppression of Menstruation.*—The first sign of pregnancy is usually the suppression of the menses. Cazeaux, indeed, was accustomed to attach some importance to the more voluptuous sensation and the more general erethism alleged to be characteristic of fruitful coition. As the human female is essentially passive in the act of conception, these phenomena are destitute of diagnostic significance. Suppression of the menses in perfectly healthy women who have been previously regular is a strongly presumptive sign of pregnancy, and the degree of probability increases with the duration of the period of amenorrhœa. The sign is of great practical value, inasmuch as it affords probably the most reliable datum upon which to predict the day of confinement.

It is subject to three familiar fallacies:

1. Menstruation may be arrested by causes other than pregnancy. Change of climate, exposure to cold, mental impressions, certain morbid states, are frequently operative in the suppression of the menses independently of pregnancy. It is a matter of common observation for perfectly healthy English women emigrating to America to miss one or two periods as the result of the change in climatic relations. Intense desire for offspring, as in newly-married women, or extreme fear, as in unmarried females who have subjected themselves to the risk of impregnation, is not infrequently productive of a brief period of amenorrhœa. Tuberculosis deserves mention in the first line, among

the morbid conditions which arrest menstruation. Then, syphilis and anæmia from all causes are only slightly less important etiological factors in amenorrhœa than consumption.

2. Pregnancy may occur in the absence of menstruation. Conception may take place during the amenorrhœa of lactation. It has been shown that menstruation is re-established in the large majority of women who suckle their babes within six months after labor; according to Carl Braun,[1] in 71 per centum. During this period pregnancy frequently occurs. Hodge cites a case, coming under his own observation, of a woman who usually menstruated twice annually. She "became pregnant seven months after the last appearance of the menses and six years after marriage."[2] A girl may become pregnant before puberty; "she may bear fruit before flowers" (De la Motte). Then there are a few authentic cases on record of pregnancy after the climacteric.

3. A more or less periodic discharge of blood from the genital tract, resembling menstruation, may take place during the early months, or even during the entire period, of pregnancy. Menstruation is in all probability suspended during gestation. But hemorrhages from pathological conditions of the vaginal portion, cervical mucosa, decidua, chorion, from polypi and placenta prævia, are sometimes observed. Women are accustomed to interpret any discharge of blood from the genital canal as menstruation, and the imagination supplies the fact of periodicity when it does not actually exist. In a certain proportion of the cases of so-called pseudo-menstruation during the first three months of gestation, before the union of the decidua vera and decidua reflexa, the pathological condition consists in a chronic decidual endometritis, sometimes of a catarrhal, sometimes of a hemorrhagic, character.

In forming an estimate of the relative diagnostic value of this sign, it is possible, therefore, to conclude that suppression of the menses in a perfectly healthy woman, previously regular, is presumptive of pregnancy in the absence of any other adequate cause. In this, in common with the other subjective signs, reliance must be placed upon the statements of the patient—obviously a very precarious basis even when there is no motive for deception.

Morning Sickness.—Nausea or sickness in the morning upon rising from the recumbent posture, sometimes accompanied by retching or vomiting, with the bringing up of some glairy fluid, is usually noticed about the beginning of the second month. Infrequently, the symptom is observed during the afternoon and very soon after conception. Morning sickness is most marked in primiparæ, in women of highly nervous temperament, occurs in considerably more than one-half the number of cases, and ceases commonly between the third and fourth months, very seldom persisting throughout gestation. In a small pro-

[1] *Lehrb. d. g. Gyn.*, Wien, 1881, p. 211. [2] *A System of Obstetrics*, p. 71.

portion of cases ptyalism occurs in connection with morning sickness. Dewees attached some diagnostic significance to spitting a white frothy mucus—"cotton spitting," as he termed it. Toothache during pregnancy may be a purely functional disorder. In the majority of cases, however, actual caries is present. During gestation the secretions of the buccal cavity are frequently altered and become sufficiently acid to dissolve the lime salts out of the enamel. Again, when for any reason an insufficient quantity of lime salts is ingested with the food, the fœtus is supplied with ossific material derived in part from the maternal teeth. Popular recognition of these dental changes has given origin to the familiar saw, "For every child a tooth." A case of early pregnancy has recently come under the writer's observation in which the condition was inferred by the patient's dentist from the changes in her teeth.

Morning sickness, associated with amenorrhœa, in the absence of any sufficient morbid cause, is a presumptive sign of pregnancy, of value chiefly on account of its early occurrence.

2. Objective Signs.—*Changes in the Mammæ.*—About the end of the second month, according to Montgomery, the nipple swells, becomes turgid, more erectile, and projects forward. It increases in sensibility and deepens in color. The apex is sometimes covered with minute branny scales, formed by the drying of the colostrum, a few drops of which can be made to exude, by dextrously compressing the gland from the base toward the nipple, as early as the third month. (See Plate.)

The areola enlarges and swells, becoming puffy and presenting the appearance of emphysematous tissue. Its color deepens, being darker in women with black hair and eyes and in brunettes than in blondes. In the negress the areola becomes jet black. The sebaceous glands of the areola, ten to twenty in number, increase in size and appear as papular elevations above the level of the skin. They are described by Montgomery as miniature mammary glands intimately connected with the lactiferous ducts, and their secretions keep the areola moist.

Toward the fifth month a secondary areola is frequently formed in brunettes around the outer margin of the primary areola. It consists of a number of round white spots arranged in a circle, presenting an appearance commonly described as resembling that of dust-covered white blotting-paper from which the dust has been discharged by a shower of water-drops. These spots are free from pigment, and each one has in its centre a small black spot, indicating the orifice of a sebaceous gland and the position of a very minute hair.

At the same time with these changes the mammary glands increase in size, become firmer in consistence, and painful spontaneously or on pressure. Blue veins are seen under the skin pursuing their tortuous courses from the nipple toward the periphery. At a later period, when

Brunette æt 19.
1st Pregnancy.

Dark Brunette æt 18.
1st Pregnancy

Dark Blonde æt 25
1st Pregnancy

Young Blonde
2nd Pregnancy.

Light Blonde
2nd Pregnancy

Appearance of the Areola in Pregnancy.

Spiegelberg

the gland attains greater proportions, lineæ albicantes often make their appearance.

It is not uncommon to see the breasts diminish in size about the fourth or fifth month, and remain in this state until term. In certain cases, especially in elderly primiparæ, the changes in the volume of the glands are insignificant, and then the function of lactation is seldom perfectly established.

There is nothing remarkable in the causation of these mammary changes, inasmuch as the breasts constitute a part of the genital system. Direct anastomotic communication exists between the arteries supplying the mammary glands and those distributed to the uterus and ovaries. The perforating branches of the internal mammary artery supply in part the mammary gland. The superior epigastric artery, one of the terminal branches of the internal mammary, anastomoses with the inferior epigastric, which arises from the external iliac a few lines above Poupart's ligament. The inferior epigastric sends off a spermatic branch which passes along the round ligament and anastomoses with the ovarian artery derived from the aorta and the uterine artery derived from the anterior trunk of the internal iliac. The nervous communication is effected through the sympathetic and spinal nerves.

The chief fallacy to which this sign is liable depends upon this intimate relationship between the mammæ and the genitalia. Certain morbid conditions of the uterus and ovaries sometimes induce such profound nutritive disturbances that mammary changes, similar in kind and differing only in degree from those incident to pregnancy, ensue. Thus in many cases of chronic metritis, of rapidly-growing uterine myomata, of ovarian cystomata, the mammary phenomena are prominent symptoms. Now, while at the fourth or fifth month, or later, the mammary changes incident to pregnancy are usually so well marked that there is seldom any difficulty in recognizing their origin, especially in primiparæ, yet in early pregnancy—during the first twelve weeks—the appearances due to pathological conditions of the uterus and ovaries are frequently so nearly identical in kind and degree that the differentiation is impossible and the sign altogether invalidated.

Tingling sensations and slight swelling of the mammary glands, with the oozing of a drop of sero-lactescent fluid in exceptional cases, are not infrequent phenomena of menstruation in women of highly nervous temperament.

In multiparæ the darkening of the areolæ, the prominence of the mammillary tubercles, and the erectility of the nipple remain in some degree permanent, and colostrum is very frequently present many years after the cessation of lactation. The sign accordingly is almost destitute of diagnostic significance during the early months of gestation in women who have borne children.

The mere presence of colostrum in the breasts of women who have not borne children is never a sign of decisive value. Baudelocque presented to the Academy of Surgery of Paris in 1783 a female child eight years old who had suckled a little brother for more than a month. It is alleged that milk has been found in the breasts of adult males. Tanner says that "it is not uncommon in Western Africa for young girls who have never been pregnant to regularly employ themselves in nursing the children of others, the mammæ being excited to action by the application of the juice of one of the Euphorbiaceæ." Sexual intercourse and mechanical irritation of the mammæ act as stimuli to the lacteal secretion, as in the case of nulliparous puellæ publicæ. In this class of women the appearance of colostrum in the absence of pregnancy is a matter of common observation.

The diagnostic value of the changes in the mammæ as a sign of early pregnancy is accordingly limited to cases of primiparæ. In these women the sign acquires decisive value just in proportion as it is possible to eliminate the fallacies mentioned. In the large majority of cases it is only a presumptive sign. During the second half of pregnancy its diagnostic significance is greater in both primiparæ and multiparæ, and when well marked may be included among the certain signs. The anecdote is related of John Hunter that on inspecting the mammæ of a young girl whose body was arranged for a post-mortem examination, he pronounced her pregnant. The hymen was found to be intact, but upon opening the abdomen the diagnosis was verified.

The advantages of the mammary changes as a sign of pregnancy over other objective alterations consist in their early and almost constant occurrence, and in the possibility of examination of the breasts without exciting the suspicion of the patient. The negative value of the sign is sometimes as great as the positive information it affords. Thus, in the entire absence of changes in the mammæ, especially in women with dark hair and eyes, we are occasionally enabled to deny the fact of pregnancy at all advanced. Then, in the diagnosis of pregnancy during the amenorrhœa of lactation—always a serious and very frequently an embarrassing problem—the negative value of the sign is obviously great. Tyler Smith remarks on this subject: "Suppression of the milk in persons who are nursing and liable to impregnation is a more valuable sign of pregnancy than the converse condition."

Changes in the Genitalia.—*Violet Hue of the Vagina.*—The violet hue of the vaginal mucous membrane, commonly compared to the color of wine-lees, has been described as a sign of early pregnancy, particularly by Jacquemin and Kluge.[1] The latter observer apparently directed his attention to the "bluish coloration of the vagina at the cul-

[1] Sommer: *Berl. Med. Central Zeitung*, Jan. 14, 1837.

de-sac surrounding the os uteri." English systematic writers since have mentioned the sign casually, but, with the exception of Robert Barnes,[1] have not attached to it special diagnostic significance. Chadwick[2] has recently called attention in an admirable paper to the value of the bluish coloration of the vaginal entrance, and particularly of the anterior vaginal wall just below the meatus urinarius, as a sign of early pregnancy. As described by this observer, the color begins as a pale violet in the early months, in contrast with the usual pinkish hue of the vaginal mucosa, becoming more bluish as pregnancy advances, until it often assumes finally a dusky, almost black, tint.

This change in coloration is due not so much to pigmentation and the stasis of venous blood as to actual hypertrophy of the corpus cavernosum vestibuli and the venous plexuses of the vaginal walls.

Although probably always present late in gestation, the time at which this sign makes its first appearance varies greatly. According to Kluge, the bluish coloration of the vaginal vault begins as early as the fourth week, or "at the time when menstruation would have occurred had conception not taken place." Out of the 281 cases of pregnancy observed by Chadwick, the changes were *suggestive* of pregnancy in 34 per centum at the end of the second month, but *diagnostic* in only 13 per centum. At the end of the third month the color was *suggestive* of pregnancy in 27 per centum, and *diagnostic* in 46 per centum. Out of 141 cases of pregnancy observed by Farlow,[3] the blue color was suggestive of pregnancy in 1 case at the end of the sixth week. Out of 22 cases, it was suggestive at the end of the second month in 10, and diagnostic in 1; out of 28 cases, it was suggestive in 5 at the end of the third month, and characteristic in 11.

The sign is obviously not infallible. It is frequently absent early in pregnancy, and its later presence is of little practical value. Chadwick was unable to discover the blue color in 17 per centum of the cases at the end of the third month; Farlow, in a still greater proportion of cases.

Then, causes other than pregnancy may produce nearly identical appearances. Montgomery has observed a blue coloration of the vagina after menstruation; and it is a familiar fact that cattle-breeders determine whether or not an animal is in heat by inspection of the vulvar orifice and the vagina. Under these conditions the mucosa is frequently black as ink (Tarnier). Chadwick reports one case of erotism with the occurrence of a bluish coloration sufficient to give rise to doubt. Vaginal cicatrices, not at all infrequent in women who have borne children and have been the subjects of the forceps operation, con-

[1] "Diagnosis of Early Pregnancy." *Brit. Med. Journ.*, 1868, vol. ii. pp. 631, 632.

[2] *Trans. Am. Gyn. Soc.*, vol. ii., 1886, p. 399.

[3] *The Boston Med. and Surg. Journ.*, vol. cxvii. No. 3, 1887.

stitute a source of error. Finally, the stasis of venous blood, as in certain cases of chronic metritis and of uterine myomata, sometimes causes a cyanotic hue which it is utterly impossible for the unskilled observer to differentiate from that incident to pregnancy.

Notwithstanding its fallibility under the conditions indicated, it must be admitted that the sign is of great practical value, especially to the acute observer.

Its diagnostic value is well expressed in the conclusions deduced by Chadwick:

"1. That its absence is not to be accepted as evidence that pregnancy does not exist, especially in the first three months, when satisfactory evidence is most needed.

"2. That from (and including) the second month this color is generally present, and often of such character as to be diagnostic."

As largely a vital phenomenon, and only in a minor degree dependent upon mechanical obstruction, it would seem probable, on *a-priori* grounds, that the sign is of value in the diagnosis of extra-uterine pregnancy. As a matter of fact, Chadwick has found the blue coloration "suggestive" as early as three and a half months in two cases of ectopic gestation.

The presence of this sign is of evident value in women with very fat or tense abdominal walls and in cases of conception during the amenorrhœa of lactation. In a case of the latter description recently coming under the writer's observation the diagnosis of pregnancy was established by the presence of this blue coloration.

Softening of the Vaginal Portion.—Early in pregnancy the vaginal portion begins to grow softer from below upward, the change in consistence being particularly marked in multiparæ. The examining finger is sometimes able to detect a peculiar velvety softness of the superficial portion of the lips of the os as early as the sixth week in women who have borne children; at the same time, the terminal phalanx may be introduced within the more or less patulous os. The alteration in density is present in some degree in almost all normal cases at the end of the third month. During the latter weeks of gestation the vaginal portion frequently does not differ sensibly in consistence from the vaginal walls.

The change in density is due to the congestion of the uterus, the tissue-changes, increased secretion of the cervical glands, and especially to the serous infiltration caused by the intermittent uterine contractions.

The sign is absent during early pregnancy in certain morbid states of the vaginal portion, as in hypertrophic elongation, and it may result from various causes, as hæmatometra, acute metritis, and the like.

Holst and Goodell have attached considerable diagnostic value to this sign. The latter observer has even given the off-hand rule: "When the cervix is as soft as one's lips, the woman is probably pregnant; when it is as hard as the tip of one's nose, the womb is most likely empty"—a rule capable of general application only during the second and third trimesters. The negative value of the sign, as indicated by Goodell, is often of some importance in the diagnosis of pregnancy during the latter months. Given a case of uterine enlargement corresponding to the seventh or eighth month, and of persistence of the vaginal portion in its original length and consistence, the non-existence of advanced pregnancy can usually be safely inferred. During the first three months the softening of the vaginal portion affords evidence only of a probable nature.

Softening and Compressibility of the Lower Uterine Segment.—Hegar[1] has recently described an alleged new and reliable sign of early pregnancy, which consists in changes in the lower uterine segment. The lower uterine segment becomes softer and more compressible in contrast with the thick, dense cervix below and the corpus above. These alterations are most marked in the median section of the lower uterine segment, while the borders remain relatively dense, appearing at times like cords. The compressibility of this median section is asserted to be sometimes so great that the mass of tissues grasped between the fingers seems to be no thicker than a visiting-card, or actual solution of continuity between the body of the uterus above and the neck below is apparent. Martin and Horwitz had previously described softening and compressibility of the lower uterine segment in hypertrophic elongation of the cervix uteri during gestation. Both observers admit that these changes may be so great as to create the impression of the existence of two distinct and separate tumors, the lower one corresponding to the hypertrophied neck, the upper one to the corpus uteri. However, they interpreted the phenomena as being pathological, and not physiological.

This sign, it will be noted, is perfectly distinct from the sensation of uterine fluctuation through the anterior uterine wall dependent upon the presence of liquor amnii. Rasch[2] asserts that this fluctuation can always be felt as early as the second month, and attaches to it considerable diagnostic importance.

According to Compes,[3] Hegar's assistant, to elicit the sign under discussion the index finger of either hand is introduced within the rectum, while the thumb of the same hand is placed upon the vaginal portion. The index finger passes above the utero-sacral ligaments, marking the boundary between the cervix and the lower uterine segment, into the pocket of the sphincter ani tertius. If the aperture of the sphincter ani tertius is not readily found, one-fourth of a liter of

[1] Reinl: *Prager medicin Wochenschr.*, 1884, No. 26.
[2] *Brit. Med. Journ.*, vol. ii., 1873.
[3] *Berl. klin. Wochenschr.*, 1885, No. 38.

lukewarm water injected into the rectum facilitates the search. The other hand, placed on the abdomen, presses the uterus downward against the finger in the rectum, when the lower uterine segment, the cervix, and the corpus uteri can be easily touched. Reinl records six cases of the diagnosis of early pregnancy by this sign alone. Compes describes eight cases in which the sign was sufficient to establish the fact of pregnancy. In one case the diagnosis was made as early as the seventh week.

The cause of these changes lies in the thinness of the lower uterine segment—the thinnest portion of the entire uterine body—the softening and œdema incident to pregnancy, and the great elasticity of the uterine contents and of the walls of the upper uterine segment, which permit the egg to be pressed upward.

Any attempt to fix the limitations and to point out the fallacies to which this sign is liable at present would be premature. The facts in our possession as to its occurrence and diagnostic significance are entirely too meagre to warrant generalizations. In passing it may be said that Compes failed to detect the sign in one case of early pregnancy, and observed phenomena somewhat similar in cases of retroversion of the uterus. Obscure and confused notions as to the objective changes embraced under Hegar's sign have rendered invalid the conclusions of certain American observers.

Changes in the Uterine Tumor.—Changes in the size, form, position, consistence, and elasticity of the uterine tumor—facts elicited upon bimanual exploration—yield valuable evidence in the diagnosis of early pregnancy. At the end of the third month the uterus forms a fig-shaped tumor the size of the head of a mature fœtus, of a certain dough-like softness and elasticity, which to the educated touch is well-nigh characteristic. When in normal position the fundus is a few lines above the plane of the inlet and inclined forward, while the cervix is tilted backward, upward, and to the left of the median line, the entire organ being in a state of physiological anteversion or anteflexion. This nutation of the fundus causes a slight elevation upward and backward of the posterior vaginal wall, while the anterior vaginal wall is rendered slightly convex downward, and is put upon the stretch—the "anterior vaginal roof-stretching" of Robert Barnes. In some cases these alterations can be detected as early as the eighth week, but they are more generally available at the period just indicated.

To elicit these signs favorable conditions with respect to the position of the uterus, and more particularly with respect to the flaccid state of the anterior abdominal wall, are necessary. In women with a very fat or tense abdominal wall it is usually difficult, and frequently impossible, to detect these alterations without the aid of anæsthesia.

The morbid states which sometimes produce closely similar changes are chronic metritis, submucous or intramural fibroids, and hæmatometra. Chronic metritis may be usually excluded by the greater density and sensitiveness of the uterine walls, subjective symptoms, and the history of the case. But pregnancy frequently occurs in a uterus in the state of chronic infarct with relatively dense and sensitive walls—an obviously perplexing situation.

In submucous and symmetrically parietal fibroids the relatively hard consistence of the uterine walls and the history of the case aid in the differential diagnosis. In cases of soft myomata or of pregnancy in uteri, the loci of myomata, the diagnosis becomes very difficult. Hæmatometra yield to the examining finger the sensation of a tense cyst, sometimes of fluctuation. Then the anamnesis in these cases is of especial value.

Alternations in density, due to the intermittent contractions of the uterus, aid materially in the differential diagnosis. This sign will be discussed in the succeeding pages. Then the rapid rate of growth of the uterine tumor in pregnancy—a fact brought out by repeated examinations—is not simulated by any of the morbid states mentioned.

The diagnostic value of these symptoms, obviously great, has risen much in the estimation of the profession in recent years since bimanual exploration is so frequently and so generally practised under the influence of gynecology. Subject to the fallacies mentioned, the alterations in the size, form, position, consistence, and elasticity of the uterine tumor may be said to approach more nearly to the rank of a certain sign than any one group of the symptoms of pregnancy enumerated in this section as occurring during the first trimester. Schroeder,[1] indeed, goes so far as to say: "The pregnant uterus is so characteristically soft, almost dough-like, from the second to the fourth month that in cases in which this change is present in a pronounced degree pregnancy is positively demonstrated."

Upon looking over the various phenomena which appear during the first trimester, it is evident that not one symptom or group of symptoms, considered in itself, constitutes, strictly speaking, a certain sign of pregnancy. There is not one upon which, in the absence of all others, the fact of pregnancy may be positively predicated. All the signs hitherto discussed afford more or less highly probable evidence. Nevertheless, the evidence cumulative from all these symptoms is amply sufficient in the large majority of cases to enable the expert observer to build up by synthesis a diagnosis of such a high degree of probability as to vary from an absolutely positive diagnosis by less than any assignable difference just before or at the expiration of the first three months. "If," says Schroeder,[2] "the uterus is found, upon bimanual exploration, of a size corresponding to the period of time (end of the

[1] *Lehrb. d. Geburtsh.*, 9te Auflage, Bonn. 1886, p. 109. [2] *Loc. cit.*, p. 110.

third month), in a position of slight anteflexion, non-sensitive, of a peculiar consistence—if the woman is perfectly healthy, and if the previously regular function of menstruation has been suppressed for a corresponding period of time—the diagnosis of pregnancy is certainly established."

II. Second Trimester.

1. Subjective Signs.—The morning sickness commonly disappears spontaneously between the third and fourth months, and, in general, a subsidence of the so-called sympathetic disorders is observed during the second trimester.

2. Objective Signs.—*Changes in the Mammæ.*—The mammary changes become more pronounced. The secondary areola makes its appearance in women with dark hair and eyes about the fifth month. Lineæ albicantes are seen in cases of considerable mammary development. The occasional shrinking in the volume of the breasts about the fourth or fifth month in the absence of any apparent cause has been mentioned. At the end of this period the changes in the mammæ usually constitute a certain sign of pregnancy in primiparæ.

Intermittent Uterine Contractions.—Tyler Smith, among others, has described the peristaltic action of the uterus during pregnancy. Braxton Hicks, in a communication to the London Obstetrical Society in 1871, called attention to the fact that during the entire period of gestation the uterus contracted and relaxed at intervals usually varying from five to twenty minutes, and to the value of these phenomena in the diagnosis of normal and complicated pregnancy. Usually the duration of each contraction is from three to five minutes. These alternations in density seldom become sensible before the end of the third or the middle of the fourth month, and even then the flaccid state is often so complete that the sensation of all resistance is lost, except to very careful bimanual examination.[1] To elicit this sign before the end of the fourth month it is necessary to practise bimanual palpation. After this period the hand is placed upon the lower abdomen, and the woman, in the recumbent position, is made to breathe deeply and freely. During expiration the uterine tumor can be outlined and the intermittent uterine contractions readily perceived.

Braxton Hicks[2] has pointed out the alterations these contractions make on the respiratory wave of the abdomen. Then they produce important effects, especially during the latter weeks of pregnancy and

[1] J. Braxton Hicks: "On the Contractions of the Uterus throughout Pregnancy, and their Value in the Diagnosis of Pregnancy, both Normal and Complicated," *Transactions of the Ninth International Medical Congress*, 1887.

[2] "Note on the Auxiliary Forces concerned in the Circulation of the Pregnant Uterus in Woman," *Proceedings of the Royal Society*, No. 195, 1879.

the beginning of labor. During a contraction the uterus becomes anæmic. Braune's plane frozen sections show that the vessels of the walls of the uterus caught in diastole are filled with blood; when caught in systole the vessels are empty. Two important functional changes result. The blood, surcharged with carbonic acid, is displaced, and a renewal of the circulating fluid is permitted. The blood, squeezed out of the uterus, first distends the capillaries of the adjacent vascular areas of the cervix and vagina. A serous exudation occurs, resulting in softening of these structures and increased mucous secretions—changes having an important influence upon the process of labor. These phenomena constitute what has been termed "vital dilatation."

The only morbid states at all likely to simulate these contractions are hæmatometra and soft uterine myomata. The distended bladder is not worthy of serious consideration, since its evacuation ought to be insisted upon before any attempt is made to elicit the sign. In hæmatometra the peristaltic action of the uterus is very feeble and seldom perceptible. In cases of collections of blood within the cavum uteri the walls of that viscus are passively distended and do not undergo any appreciable hypertrophy. The exclusion of such tumors, as a rule, is accordingly possible.

But in rapidly-growing soft fibroids the differential diagnosis is usually difficult, and sometimes impossible. The contractions in soft myomata are usually the result of manipulation, and do not possess the same constant and spontaneous character as those of the pregnant uterus. Repeated examinations, with precautions against needless manipulation, usually clear up the obscurity in diagnosis.

Diagnostic value of a high degree must be attached to this sign. It is always present, and is usually perceptible early in pregnancy. It is completely independent of the life of the child, being observed in cases of degeneration of the ovum and of retention of the dead fœtus within the cavum uteri. In the pregnant uterus, with foci of myomatous tissue, the alternations of density in the normal musculature can be felt, while the consistence of the fibroids undergoes no sensible change. The assertion has been made that the presence of these intermittent uterine contractions demonstrates the normal or intra-uterine character of the pregnancy. This statement is not strictly accurate. In ectopic gestation of the abdominal variety an adventitious uterus is usually developed, which is composed of the same morphological elements as the normal uterus. On *a-priori* grounds there is every reason to believe that intermittent contractions occur in this adventitious uterus, just as they do in the normal organ. They are, however, probably more feeble.

The sign is of very great value in cases of hydramnios. When the excess of liquor amnii is great, and the fœtus too small to give signs of its life, the resemblance of the uterine tumor to an ovarian cyst may become very close. Charpentier[1] cites a case coming under his own observation of rapid abdominal enlargement in a woman whose menstruation had been suppressed for three months. No modifications of the vaginal portion were perceptible, and other possible signs of gestation were masked by a grave thoracic disease. The diagnosis was null until on palpation alternations in the density of the tumor were noted, when the condition of acute hydramnios in the third month of pregnancy was recognized. Pregnancy was at once artificially interrupted, and twin fœtuses corresponding to the twelfth week were removed from the cavum uteri, together with fifteen liters of fluid.

Braxton Hicks has recently described a peculiar condition of the gravid womb in which, at about the fifth month, the uterus is very flaccid—"scarcely to be felt except at one part, where a firm lump is to be felt"—during the interval between contractions. This condition he finds very often associated with the death of the fœtus. The diagnosis under these conditions lies between simple pregnancy, pregnancy complicated by a tumor, and ectopic gestation. If the hand is placed upon the womb until that organ contracts, the whole mass is transformed into a solid ball. The more solid portions merely mark the position of the placenta.

Lawson Tait[2] declares that "this is an infinitely more certain sign than the fœtal heart or the sound of the placental bruit." Now, as at present informed, no such sound as the placental bruit exists in nature, and the literal significance of Mr. Tait's words amounts to an absurdity. Still, we may construe the sentence as a figurative expression for the great value attached by the speaker to this sign. The deliberate opinion of such an observer of enormous experience is justly entitled to a high degree of consideration.

Inasmuch, however, as the intermittent uterine contractions are closely simulated by at least one morbid state, more particularly during the early months, the symptom cannot be classified among the certain signs of pregnancy.

Active Fœtal Movements.—The sensation communicated to the mother by the spontaneous movements of the fœtus is popularly known as "quickening," since it was formerly erroneously thought that at this time life was imparted to the embryo. Active fœtal movements are usually first felt by the mother—suddenly in very many cases—about the sixteenth week, the time varying within wide limits, although they really commence at a very early period of embryonal life—as soon as the muscular tissue is developed sufficiently to contract. It is generally

[1] *Transactions Ninth International Medical Congress.*

[2] *Transactions of the New York State Medical Association*, Albany, 1886.

believed that the maternal recognition of the phenomena depends upon the contact of the uterine tumor with the anterior abdominal wall and the transmission of the fœtal impulse through the sensory nerves. The sensation, when first experienced, is commonly described as being like the feeble fluttering of a bird held in the closed hand. As pregnancy advances the movements become more manifest, consisting of a series of short, sharp strokes or kicks, which often give origin to unpleasant sensations and even positive pain, more particularly in primiparæ of highly nervous temperament. Palpation under favorable conditions enables the examining physician to detect fœtal movements at the end of the twelfth week, long before the mother feels them. As gestation proceeds these active movements may be heard and even plainly seen. Prior to the fourth month the sign may be occasionally elicited upon bimanual palpation or vaginal stethoscopy; after this period by abdominal palpation. The anecdote is related of the late Charles Budd of New York that upon meeting several eminent physicians in consultation over an obscure case of abdominal enlargement, he placed his hand on the cold window-glass and then gently applied it to the patient's naked belly. Immediately he felt a series of short, sharp strokes, and the diagnosis was at once cleared up. The story affords a valuable hint in practice. Sometimes, however, the sudden impression of cold causes rapid contractions of the abdominal walls or of the uterus, obscuring the sign. The movements consist in flexions and extensions of the trunk and upper and lower extremities.

The causation of the spontaneous movements of the fœtus is not definitely known. Braxton Hicks is of the opinion that there is some closely constant relationship between the highly carbonized blood-accumulation in the uterine veins and the fœtal movements, and between the fœtal movements and the intermittent contractions of the uterus. Their force and frequency vary greatly in different individuals, and in the same individuals at different periods of the day. Usually, they are more manifest upon rising from bed in the morning. It is certain that their force and frequency increase after prolonged abstinence from food and just prior to death from asphyxia. Certain positions of the body also seem to influence these manifestations. From being very active, they may cease entirely for days at a time, and still the fœtus may be in a perfectly physiological state. Sudden and complete cessation of all movements is often coincident with the death of the child. The sudden and complete cessation of these phenomena, however, is also observed as the result of the operation of unknown causes which do not affect the vitality of the child. Many cases are recorded in which the movements have never been perceived by the mother nor felt by the medical attendant, and yet perfectly healthy children have been borne (Mauriceau, De la Motte, Cazeaux, Fouquier, Campbell). It has been suggested that the movements actually occurred during sleep, and were not brought to the maternal consciousness.

Certain pathological conditions may interfere with the perception of the fœtal movements, both by the mother and the physician. Thus, in hydramnios and ascites their recognition is usually difficult and occasionally impossible.

Viewed as a subjective symptom, quickening as a sign of pregnancy is liable to many and essential fallacies. Irregular contractions of the abdominal muscles, the peristaltic action of the intestines—particularly when distended with gas—a wandering kidney, cause sensations which the woman so frequently interprets as being of fœtal orgin that little diagnostic significance attaches to her perception. The symptom, however, has a limited value as sometimes furnishing one of the data upon which the day of confinement may be predicted.

When felt—and especially when seen and heard—by the expert observer, the active movements of the fœtus constitute a sign absolutely diagnostic both of pregnancy and of the life of the child. No normal or abnormal state of the abdominal muscles nor of the abdominal viscera imparts to the hand at all experienced in palpation sensations that can easily be confounded with active fœtal movements. Their absence, however, does not demonstrate that pregnancy does not exist nor that the fœtus is not alive.

Passive Fœtal Movements.—Movements may be communicated to the fœtus surrounded by the liquor amnii, and its passive reaction often constitutes a valuable sign of pregnancy. These passive fœtal movements are technically known as the phenomena of ballottement or repercussion. The sign is generally available from the fourth to the eighth month. Before this period the fœtus is relatively too small and the uterine walls too thick; after the eighth month the fœtus is relatively too large to float upward in the normal quantity of liquor amnii. Exceptionally, the sign can be elicited as early as the middle of the fourth month. Passive movements of portions of the fœtal body may be perceived up to the time of engagement of the presenting part within the pelvic inlet.

According as the phenomena of repercussion are elicited by vaginal exploration or by abdominal palpation we have the methods of internal and external ballottement. The former is much the more valuable of the two as regards diagnosis, inasmuch as it can be successfully practised before the uterus constitutes an abdominal tumor of considerable size. The latter method is occasionally applied in the differential diagnosis of large abdominal swellings.

To practise internal ballottement, the woman is placed in the lithotomy position, and the index finger, or two fingers, of the right hand are applied to the anterior vaginal wall at the plane of the junction of the cervix with the corpus uteri, while the left hand gently presses the fundus downward. The intravaginal finger suddenly and quickly presses from below upward and from behind forward the anterior uterine wall in the direction of its long axis. The entire body of the fœtus is thus displaced, floating upward until it reaches the fundus, when its impact may be felt by the left hand. The recession of the mass—usually the head—filling the lower uterine segment is perceived by the intravaginal finger. In a moment the return tap of the presenting part is felt. Depaul lays particular stress upon the sensation imparted by the departure of the head from its customary resting-place, and attaches less significance to the *choc en retour* which Pajot especially emphasizes. As remarked by Charpentier,[1] Depaul practises cephalic ballottement, while Pajot displaces upward the entire body of the fœtus.

In external ballottement the woman is placed upon her back, and the two hands are applied to the opposite sides of the uterus. Then a sudden, quick stroke of one hand displaces the body of the fœtus toward the other hand, just as a lump of ice floating in a glass of water is displaced by a tap with the finger. Or the woman may be placed in the lateral position, with her belly overhanging the edge of the bed. One hand is placed upon the upper side of the uterus, while the fingers of the other hand rest upon the lower side. The sensation of the recession of the fœtal body and the *choc en retour* are more distinctly perceived in this position than in the former.

It is difficult—sometimes impossible—to elicit ballottement by the vaginal method when the fœtus is abnormally large or very small, in cases of excess and deficiency of the liquor amnii, in placenta prævia, in multiple pregnancy, and in pelvic and transverse presentations.

The fallacies to which the sign is liable are numerous and not unimportant. A multilocular cystoma of the ovary (Pajot), a small ovarian cyst with a long pedicle, the non-pregnant anteflexed uterus (Cazeaux), the pregnant womb itself (Robert Barnes) floating in ascitic fluid, a wandering kidney, a calculus resting in the bas-fond of the bladder (Cazeaux), have actually caused sensations analogous to those of repercussion. It is usually possible, however, to exclude these sources of error.

The sensation of ballottement when elicited by an expert observer may be regarded as a certain sign of pregnancy. However, it affords no information as to the life or death of the fœtus, and its absence does not disprove the fact of pregnancy. Accoucheurs of the Paris school employ the sign more frequently and attach greater diagnostic significance to it than do American, German, and English observers. At the time when the methods of repercussion are capable of application other signs, yielding more adequate information, are commonly present.

[1] *Traité pratique des Accouchements,* tome i. p. 290, Paris, 1883.

Palpation of the Fœtal Body.—In the abdominal palpation incident to the discovery of intermittent uterine contractions, the active and passive movements of the fœtus, and the like, it is often possible to directly outline the entire or various portions of the fœtal body during the intervals between the painless contractions of the womb. Thus, the head is sometimes felt through the anterior vaginal wall as early as the fourth month.[1] Budin[2] suggests that by pressure on the fundus in cases of longitudinal presentation the normal curvature of the fœtal body is increased and the palpation of the back rendered easier. Attention has already been called to the detection at the fifth month of the placental site by Braxton Hicks.

Many years before the systematic application of abdominal palpation to obstetrical diagnosis Oppolzer called attention to, and happily illustrated in his bedside lectures, the marvellous possibilities in the evolution of tactile sensibility and its general diagnostic utility. The anecdote is narrated of him by one of his former internes (Chrobak) that upon one occasion a patient was brought into his clinic suffering from an obscure abdominal enlargement. Oppolzer seized a portion of the tumor between his fingers, at once pronounced it intestine, and sent the patient to the first surgical clinic to be operated upon for hernia. The woman was speedily returned with the label "Error in diagnosis." He ordered her transferral to the second surgical clinic, whence she was promptly sent back with a like inscription. "But I felt the intestine," remarked Oppolzer; and for the second time she was sent to the first surgical clinic. According to one version of the story, the patient died during this fifth passage between the courts of the Allgemeines Krankenhaus, but the autopsy revealed the accuracy of Oppolzer's diagnosis.

Of course extreme care must be taken in the interpretation of the tactile perceptions now under discussion. Small subserous fibroids of the uterus, carcinomata of the peritoneum and omentum, and multilocular cystomata of the ovaries, especially in the presence of ascitic fluid, may closely simulate to the sense of touch the head, pelvis, and particularly the upper and lower extremities, of the fœtus. While the direct palpation of the entire or portions of the fœtal body seldom furnishes evidence of decisive value, it almost always affords significant corroborative testimony.

The Fœtal Heart-Tones.—The sounds of the fœtal heart were accidentally discovered in 1818, two years after the publication of Laennec's memoir on mediate auscultation, by Mayor, a surgeon of Geneva, while trying to hear the sounds supposed to be caused by fœtal movements. Lejumeau de Kergaradec, ignorant of Mayor's discovery, called attention to the same phenomena in a memoir presented to the Paris

[1] Carl Braun, *loc. cit.*, p. 115.

[2] *Progrès méd.*, 1881, 21.

Academy in 1821. This observer also was led to hear the sounds by accident; he was endeavoring to listen to sounds produced by the liquor amnii.

The fœtal heart-tones are commonly first heard about the eighteenth or twentieth week. Under favorable conditions they may be recognized as early as the fifteenth or sixteenth week, and exceptionally still earlier. Thus, Depaul asserts that he has detected them at the eleventh week; Tarnier, at the twelfth week; Routh and Verardini, by the use of vaginal stethoscopy at the twelfth week.

From the eighteenth or twentieth week they are almost always heard until the expiration of the term of pregnancy. During the last three months Depaul failed to hear them in only 8 out of 906 cases; Anderson of Glasgow, in only 12 out of 180 cases, and in all of these 12 cases the children were stillborn.

The quality of the tones is usually described as being like the tick-tack of a watch heard through a pillow. A more adequate notion, however, is easily acquired by listening to the heart-tones of a newborn child. The sound is dicrotic; the first tone, being loudest and strongest, corresponds to the ventricular systole; the second is sometimes inaudible. A very short interval of time elapses between the first and second tones, but between the second and the succeeding first tone there is a distinct pause. The cardiac cycle, so far as the tones are concerned, may be graphically represented by: tick—tack—pause.

The force of the heart's action under normal conditions seems to undergo no alteration from the time it is first heard until the expiration of the period of gestation. At the eighteenth or twentieth week the intensity of the heart-tones, subject to individual variations, is as great as at term. The distinctness with which the tones are heard in the individual case depends upon the size and development of the fœtus, the intimate relationship between the thorax and the uterine wall, the thinness of the uterine and abdominal parietes, the quantity of the liquor amnii, and the like.

The frequency of the heart's action varies within physiological limits from 120 to 160 beats to the minute. The factors which accelerate or diminish the frequency of the heart's action include numerous maternal and fœtal conditions, both normal and morbid. Active and passive movements of mother and child quicken the heart-beats. When the blood in the uterine sinuses becomes surcharged with carbonic acid, as in asphyxia, the heart-beats are at first somewhat accelerated, but soon become slow and increased in force. Winckel, Runge, and others have shown that any elevation of maternal temperature is followed by a disproportionately great acceleration of the action of the fœtal heart. Specific poisons contained in the maternal blood, as in smallpox, have an important effect. Chloroform, inhaled by the mother, passes into the fœtal blood and acts directly upon the cardiac muscle. Ergot, by causing a tetanic spasm of the uterine musculature, produces the alterations in the frequency of the heart-beats characteristic of asphyxia. During a normal uterine contraction the heart's action is accelerated in the phases of increment and decrement, but slowed during the acme, in part the result of increased blood-pressure. These phenomena are especially apparent after rupture of the bag of waters. In morbid states of the fœtal envelopes, compression of the umbilical cord, partial separation of the placenta, and the like, the alterations in the frequency of the heart-beats are chiefly those of asphyxia.

Frankenhäuser[1] in 1859 asserted that the sex of the child exerted an important influence on the frequency of the heart's action, and that the average rate of pulsation is less considerable in male than in female children. In 50 cases this observer found the average rate to be 124 in males and 144 in females. Dauzats found that when the pulsations were above 145 the child was generally a female; when less than 135, a male; when 135 to 144, the sex was uncertain. Frank C. Wilson[2] of Louisville is of the opinion, derived from extensive observation, that the sex of the child can be predicted with a reasonable degree of accuracy from the rapidity of the fœtal heart-sounds. He has found these to vary within normal limits from 110 to 170, and that "134 may be taken as the dividing-line above which the sex will be female, and below which the sex will be male, the certainty increasing the farther you recede from the dividing-point." This observer has constructed the following table:

From	110 to 125	the sex	will be,	almost certainly, male.
"	125 to 130	"	"	probably, male.
"	130 to 134	"	"	doubtful, with chances in favor of male.
"	134 to 138	"	"	doubtful, with chances in favor of female.
"	138 to 143	"	"	probably, female.
"	143 to 170	"	"	almost certainly, female.

Steinbach and Devilliers fix the average rate at 131 in males and 138 in females. Cumming,[3] Devilliers, and others conclude, however, that the difference in the rate of pulsation is determined chiefly by the size and development of the fœtus, "so that a large female child may have a slower pulse than a small male."

Engelhorn[4] is of the opinion that the frequency of the fœtal heart-beats diminishes with the increase in length of body. Volkmann's tables render this statement highly probable in the case of adults. Engelhorn's averages were as follows:

[1] *Monatschr. f. Geburtsh.*, Bd. xiv. p. 161.
[2] Parvin: *The Science and Art of Obstetrics*, Philada, 1886, p. 192.
[3] *Edin. Med. Journ.*, 1875.
[4] *Arch. f. Gyn.*, Bd. ix. p. 368.

Body-length.	Frequency of the fœtal heart-beats.
40–45 cm.	147.9
45–50 cm.	137.9
Above 50 cm.	126.6

The results of the researches of Budin[1] and Chaignot are of peculiar interest and value in this connection. Their conclusions are based upon the examination of 70 cases of normal pregnancy a few weeks before term. Male children were born in 41 cases, female in 29. The conclusions are, briefly—

1. There is no absolute relation, from a practical point of view, between the number of fœtal heart-beats and the sex of the infant. High and low numbers are found as well with the one as with the other. Least of all is there ground for the prediction of the sex of the fœtus when the number of pulsations is low; that is to say, 130 to 140.

2. If the heart-beats are counted at different times during the latter months of pregnancy, sometimes about the same number is found, but more frequently a different number is recognized at each examination. For example, in the same fœtus we have found—30th November, 160; 8th December, 138; 12th December, 128; 14th December, 134.

3. Moreover, sometimes, while the woman is remaining perfectly immobile in the horizontal position and the observer has his ear applied to the stethoscope without moving, one finds variations in the number of pulsations in successive minutes of from 15 to 25, without being able to find a cause for these variations. To such a degree is this the case that it is sometimes embarrassing to determine exactly what is the mean rate.

4. There is no foundation for the alleged relation between the weight of the child and the frequency of the heart's action. A large number of pulsations to the minute does not indicate a small fœtus, and a small number of pulsations a large fœtus. In proof we offer the following figures, the boys and the girls having been placed in the order of their weights:

Boys:	the smallest	2.175 grammes,	132 pulsations.
	the largest	4.210 "	144 "
Girls:	the smallest	2.008 "	128 "
	the largest	3.650 "	140–150 pulsations.

When we regard merely the extremes, it would seem that conclusions ought to be arrived at the inverse of those formulated by Cumming. But we hesitate to do this: the intermediary observations present such a variety that we believe there is no relation between the weight of the fœtus, the heart-beats, and the sex.

[1] P. Budin: *Obstétrique et Gynécologie*, Paris, 1886, p. 217.

To elicit the average rate of pulsation of the fœtal heart it is necessary that the perfectly healthy woman be placed in the horizontal position, that she remain as immobile as possible, and that auscultation be practised in the intervals between uterine contractions and in the absence of active and passive fœtal movements. These conditions were all fulfilled in the researches of Budin and Chaignot. They are accordingly entitled to a very high degree of consideration, and may be accepted as conclusive for the time being. The subject is well worthy of further investigation.

While, of course, the prediction of sex is a matter of comparatively trivial moment so far as practice is concerned, its physiological significance is considerable. Moreover, adequate conceptions of the normal and abnormal variations in the force and frequency of the action of the fœtal heart are of the greatest practical consequence in the determination of the time for operative interference during pregnancy and labor. Any contribution to our knowledge of the causes which affect the functions of the fœtal heart, however apparently trivial or irrelevant, is significant. Kilian in 1849 formulated what is sometimes called "the stethoscopical indication for the forceps operation:" "The forceps must be applied under favorable conditions without delay when the fœtal heart-tones diminish in frequency to less than 100 to the minute, or when they increase to 180, and when at the same time they lose their purity of tone, when distinct intermissions occur, and when only one tone can be clearly heard."

Mediate or immediate auscultation may be employed in the examination of the fœtal heart-tones. Mediate auscultation is preferable, for perfectly obvious reasons. But unless the obstetrician has had large experience with the stethoscope in listening to the fœtal heart-tones, he will find the direct application of the ear to the belly of the woman a more speedy and reliable method. In the choice of a stethoscope the practitioner will be governed by the instrument he is accustomed to employ in the physical exploration of the chest. The binaural stethoscope has certain advantages over the monaural instrument, but muscular sounds are more apt to create confusion. The stethoscope should be provided with a wide bell.

Early in pregnancy the stethoscope should be applied over the fundus in the line of the axis of the pelvic inlet, and subsequently the entire anterior surface of the uterus may be explored. During the last three months palpation usually reveals the presentation and position of the fœtus, and indicates approximately the cardiac area. The space over which the heart-beats are heard with the maximum intensity is commonly limited, being six or eight centimeters in diameter. In exceptional cases they are heard over the whole anterior uterine surface. Two areas of maximum intensity on opposite sides of the median line, with a difference in the frequency of the pulsations, are strongly presumptive of twin pregnancy. In first positions of the vertex the heart-tones are usually heard to the left of the linea alba, at about the middle of the line drawn from the umbilicus to the centre of Poupart's ligament; in right occipito-posterior positions, to the right of the linea alba, a little to the outer side of the middle of the line between the umbilicus and the centre of Poupart's ligament. In pelvic presentations the heart-tones are heard above the plane of the umbilicus, to the left or right of the median line according to the direction of the child's back. Depaul explains the fact that in cephalic presentations the heart-tones are heard below, and in pelvic presentations above, the plane of the umbilicus, upon the hypothesis that the heart is situated nearer to the cephalic than to the pelvic extremity. Ribemont, however, has demonstrated, by the plane frozen sections of fœtuses of various ages, that the heart is about equidistant from the pelvic and cephalic poles of the fœtal ovoid. Hennig[1] attaches some importance to the cranial bones, as being better conductors of sound than the fœtal pelvis.

The true explanation is to be found in the engagement of the cephalic extremity within the pelvic inlet during the last weeks of gestation. In pelvic presentations this engagement does not occur until immediately before or during labor, so that the fœtal heart remains at a higher plane. In case of excessive size of the head, prolapse of an extremity, pelvic contraction, placenta prævia, the head may not engage in the inlet during the latter weeks of gestation, and the fœtal heart-beats are often heard at or above the plane of the umbilicus. In left mento-anterior positions of face presentations and dorso-posterior positions of transverse presentations, on account of the intimate relationship between the walls of the uterus and the thorax and the transmission of the sounds through the anterior instead of the posterior chest-wall, the heart-tones are heard with extraordinary distinctness, and have even been felt by the finger of the examiner in exceptional cases.[2]

Maygrier suggested, and Nauche actually constructed, a vaginal stethoscope under the name of metroscope. This instrument, applied either to the vaginal vault or within the cervical cavity, fell into disuse, partly on account of the alleged violence to the parts. In recent years Verardini (1878) of Bologna has successfully practised intravaginal stethoscopy, without endangering the product of conception, as early as the twelfth week. In the event of failure to hear the pulsations of the fetal heart repeated trials must be made on different occasions, and their absence or disappearance alone never justifies the assumption that the fœtus is necessarily dead.

[1] *Zeitschr. f. Geb. u. Gyn.*, Bd. xi. p. 47.

[2] Fischel: *Prager med. W.*, 1881, Nos. 12, 28; Fleischmann: *Ibid.*, 1885, No. 35; Valenta: *Ibid.*, 1885, No. 45.

The only sounds that closely simulate the fœtal heart-tones are the maternal heart-tones, transmitted through the uterine tumor. Under normal conditions these are so much less frequent that the counting of the number of pulsations to the minute commonly suffices to clear up any obscurity in diagnosis. In case of elevation in temperature the acceleration in the frequency of the action of the maternal heart renders the differential diagnosis more difficult. However, if the suspected sound originates in the maternal heart, it will increase in intensity as the præcordial region is approached.

The clear and distinct recognition of the fœtal heart-sounds is an absolutely certain sign both of pregnancy and of the life of the fœtus. Their absence, however, does not warrant the assumption that pregnancy does not exist or that the child is dead. Alterations in the force, and especially in the frequency, of the heart's action afford important information as to conditions which threaten the child's life. Finally, the site at which the heart-tones are heard with maximum intensity is of great value in the diagnosis of presentation and position, as originally pointed out by De Kergaradec.

The Fœtal Souffle.—The fœtal souffle is a single or double, blowing murmur isochronous with the fœtal heart-beats, heard at or near the area of maximum intensity and in various other widely-removed regions of the uterus. According to the researches of Hecker[1] and Schroeder,[2] it occurs in 14–15 per centum of all cases. In many cases the sound originates within the fœtal heart, and is known as the cardiac souffle. It has been demonstrated to be due to hypertrophy of the right ventricle, with insufficiency of the tricuspid and mitral valves and vegetations (Virchow), perforation of the ventricular septum (Massmann, Carl Braun), passage of blood through the foramen of Botal, and to various functional disturbances (Scanzoni, Skoda, Bumm). In other cases the sound is produced within the umbilical cord, and is termed the funic souffle. By Evory Kennedy, who discovered it, Naegele, Depaul, Devilliers, Charrier, and others it has been regarded as due to mechanical interference with the circulation in the cord. Kehrer[3] succeeded in producing a systolic murmur by compression of the cord with the stethoscope in a case in which the funis was palpable between the fœtal body and the wall of the uterus.

Pinard[4] and Bumm[5] think the sound is caused by the diminution of the lumina of the umbilical vein and arteries through the hypertrophy of the semilunar valves described by Hyrtl and Berger. The funic souffle is a single, sometimes double, murmur of variable quality and intensity,

[1] *Kl. d. Geb.*, p. 27.
[2] *Schw. Geb. u. Wochenbett*, p. 17.
[3] *Arch. f. Gyn.*, xii. p. 258.
[4] *Arch. de Tocol.*, 1876, p. 310.
[5] *Arch. f. Gyn.*, Bd. xxv. p. 277.

fugacious, and usually heard at some distance from the area of maximum intensity of the pulsations of the fœtal heart.

Both sounds are absolutely diagnostic of pregnancy and of the life of the child, but neither sound constitutes an indication for operative interference. Charrier, indeed, regarded the funic souffle as a sign of impending asphyxia and as being an indication for the induction of premature labor. However, inasmuch as children are born with the cord so coiled around such parts as to be subject to compression, without the production of this sound, and still others in whom the sound was present are born with the cord in its normal relations, the indication for the induction of premature labor is not at all apparent. Winckel[1] insists upon the careful observation during labor of the cases in which the funic souffle is present, and upon early operative interference in the event of changes in the fœtal heart-tones.

Sounds due to Active Fœtal Movements.—Pajot in particular has studied the auditory and tactile sensations produced by active fœtal movements. At the end of the third month a bruit is produced comparable to the sound caused by tapping the finger against a tense membrane. This sound is the result of the total displacement of the fœtus. Toward the end of gestation the bruit is caused by partial movements, as of the extremities and head. It is then localized at the fundus. To these sounds Pajot has given the term *bruit de choc fœtal.* If the stethoscope be applied over the uterus during active fœtal movements, two phenomena are perceived—a quick but exceedingly delicate bruit, and the sensation of shock from the impact of the fœtus or its extremities against the uterine walls. The ear, struck at the same time in its general and special sensibility, receives at once a tactile and an auditory impression.

As an early sign of pregnancy the sounds are of diagnostic significance to the skilled observer. Later, they are merely interesting auscultatory phenomena.

The Uterine Souffle.—Of all the maternal bruits, the uterine souffle is of chief moment. This sound was discovered by De Kergaradec in 1821, who termed it *battement simple avec souffle.* Since that time it has been successively designated placental souffle (Monod, Ulsamer, Hohl), abdominal souffle (Bouillaud), simple pulsation (Ritgen), epigastric souffle (Kiwisch), uterine souffle (P. Dubois, Depaul, Naegele).

The uterine souffle is subject to many individual variations as regards quality, intensity, rhythm, and the site of maximum intensity. In quality it is commonly a blowing, sibilant murmur, like the bruit of a varicose aneurism. In other cases it is a soft murmur, comparable to the sound produced with the lips in pronouncing in a low voice the syllable *vous* (Depaul). The sound increases in intensity until the eighth month,

[1] *Zur Path. d. Geb.*, p. 223.

and then remains stationary. According to Depaul, it sustains no relation to the intensity of the sounds of the maternal heart, but is lessened by all causes that effect a diminution in the calibre of the uterine blood-vessels, as strong pressure with the stethoscope, active fœtal movements which compress the uterus, and uterine contractions. During a uterine contraction the souffle increases in intensity in the phases of increment and decrement, but becomes almost imperceptible in the acme. As regards rhythm, the bruit is usually single and intermittent, sometimes dicrotic and continuous. It is isochronous with the maternal pulse, and is thus readily distinguished from the funic souffle, which it closely resembles in other particulars.

The site at which the uterine souffle is heard with maximum intensity varies in different individuals and in the same individual on different occasions. It is most frequently heard with greatest distinctness low down and to one or other side, sometimes over the fundus, very seldom over the entire anterior uterine surface. Out of 80 cases observed by Jacquemier, it was more or less limited to the left iliac region in 34, to the right in 22, to the umbilical region in 4, over the anterior uterine surface in 9. Out of 395 cases of pregnant women who had passed the fifth month, observed by Depaul, the bruit was distinctly heard on each side of the uterus in 182 cases, on only one side in 27, over the fundus in 43, over the anterior uterine surface in 18, in three distinct places—over both sides and over the fundus—in 12.

The uterine souffle is commonly first heard at the end of the sixteenth week, although Kennedy, Carrière, Depaul, and Verardini have detected it as early as the tenth or twelfth week.

The causation of this souffle has been productive of numerous suppositions, of which the placental, iliac, epigastric, and uterine hypotheses are especially worthy of consideration.

1. *Placental Hypothesis.*—Laennec, Carrière, Monod, Hohl, and others localized the maternal souffle in the placenta. Hohl thought the sound was the result of the passage of the arterial blood into the placental venous sinuses. Bailly, however, has shown that the souffle persists, in nine out of ten cases, after the expulsion of the placenta for an average period of sixty-three hours. In one case it persisted six days. Bailly's observations have been abundantly confirmed.

2. *Iliac Hypothesis.*—The supposition of Haus, subsequently adopted by Bouillaud, is that the sound has its origin in the aorta and iliac arteries, and is caused by the mechanical pressure of the gravid uterus. Lahs, however, has shown that the pressure of the gravid uterus in the intervals between contractions is practically but little greater than the normal superjacent intestinal mass. The souffle has been heard as early as the twelfth week, before the uterus is high enough in the abdomen to effect mechanical compression. The irregular character,

occasional disappearance, and variable site of the souffle render this supposition highly improbable. The sound disappears during the acme of uterine contraction, instead of increasing, as it would in case of localization in the aorta and iliacs. Finally, Tarnier[1] by pressure with the stethoscope has caused the disappearance of the abdominal souffle without affecting the bruit in the femoral artery. These considerations totally invalidate the iliac hypothesis.

3. *Epigastric Hypothesis.*—Kiwisch and Glénard advocated the view that the sound was generated in the epigastric artery. Glénard asserted that compression of the epigastric caused a modification, and ultimately the disappearance, of the souffle. Tarnier replied that such a degree of compression was sufficient to compress the uterine artery also. Glénard then abandoned his hypothesis, and referred the sound to the puerperal artery, an anastomotic branch connecting the uterine and ovarian artery —a virtual reversion to the uterine hypothesis. Hecker[2] detected a systolic bruit in the epigastric in a pregnant woman. It cannot be denied that in certain exceptional cases extra-uterine murmurs are heard, but they do not closely simulate the uterine souffle.

4. *Uterine Hypothesis.*—P. Dubois localized the abdominal souffle in the walls of the uterus. This hypothesis is in harmony with the variations in quality, intensity, rhythm, and site of maximum intensity already mentioned. All the physical conditions essential to the production of such a sound are present—the tortuous parietal branches of the arteries, of greater calibre than their parent trunks; the termination of arteries in the venous sinuses, especially near the placental site; the *mélange* of rapidly-moving columns of red blood with the slowly-circulating venous blood. Finally, actual vibrations of the uterine arteries can be felt and heard per vaginam.[3] In exceptional cases the vibrations may be felt through the abdominal walls.[4]

The uterine origin of the abdominal souffle may be accordingly regarded as demonstrated, although the exact mechanism of its production is still the subject of controversy. Thus, Depaul is of the opinion that the compression of the uterine arteries by the active fœtal movements plays an important rôle. These active fœtal movements probably sustain some important relation to the intermittent uterine contractions, as pointed out by Braxton Hicks. Cazeaux and Scanzoni attach much significance to the qualitative changes in the blood of the pregnant woman.

The diagnostic value of the uterine souffle is very greatly impaired by the fact that a closely similar bruit is sometimes heard in chronic metritis, frequently in uterine myomata, and occasionally in ovarian

[1] Tarnier et Chantreuil: *Traité de l'Art des Accouchements*, p. 503.
[2] *Klinik der Geb.*, 1871, p. 31. [3] Rapin: *Corresp. Bl. f. Schweizer Aerzte*, ii. 2.
[4] Rotter: *Arch. f. Gyn.*, Bd. v. p. 539.

cystomata. The sign yields no information as to the intra-uterine location of the fœtus, as affirmed by Depaul, since Schroeder and Rizzole[1] detected the souffle in the adventitious uterus of ectopic gestation.

It affords no information as to the life of the fœtus. At best, it is merely a presumptive sign, of a certain value on account of its early and almost constant occurrence.

During the second trimester the uterine tumor assumes the form of a short ovoid or of a flattened spheroid. At the end of the fourth month the fundus is about 5 cm. above the pubes; at the end of the fifth month, about 5 cm. below the umbilicus; at the end of the sixth month, on the same plane or slightly above the umbilicus. During this period the umbilical depression grows gradually less, until at the expiration of the sixth month it is on the same level with the cutaneous surface of the abdomen or is even slightly everted. Lineæ albicantes begin to appear toward the close of the second trimester.

The vaginal portion continues to grow softer from below upward. According to Tarnier, in the primipara the lower half is softened at the end of the sixth month. At that time it is situated to the left of the median line, high up in the pelvic cavity, in the vicinity of the left sacro-iliac joint. In some cases it is situated at or even above the plane of the inlet.

The varices and œdema of the vulva and lower extremities are augmented as the result of increased intra-abdominal pressure.

III. Third Trimester.

During the third trimester all the objective changes heretofore described in connection with the mammæ and the genitalia are intensified.

At the end of the seventh month the fundus extends about 5 cm. above the umbilicus; the average circumference of the abdomen in the region of the navel measures 91 cm.; midway between the navel and the symphysis, about 94 cm.; the average distance between the xiphoid process and the pubes is 42 cm. (Schroeder). The vaginal portion in primiparæ is softened in its lower three-fourths. The cervical canal, closed in primiparæ, is frequently pervious for the index finger in multiparæ.

The head may usually be felt in primiparæ, occupying the lower uterine segment.

At the end of the eighth month the fundus is about 5 cm. below the ensiform process. The average circumference of the abdomen in the region of the umbilicus measures 95 cm., midway between the navel and the symphysis, 97 cm.: the average distance between the ensiform process and the pubes is 43½ cm. The abdominal walls are tense in

[1] *Ann. d. l. Soc. Méd. Disc. de Liège*, 1880.

the primipara, and the umbilical ring is slightly convex. The entire vaginal portion in primiparæ is softened, and the head is felt above the inlet just about to engage.

At the end of the ninth month the fundus has attained its highest elevation, near the ensiform process. The average circumference of the abdomen in the umbilical region measures 97½ cm., midway between the navel and the symphysis, 99 cm.; the distance from the ensiform process to the symphysis is 44 cm. The umbilicus becomes more convex. The os externum in primiparæ is pervious for the terminal phalanx of the index finger; in multiparæ the finger readily passes through the cervical canal to the isthmus of Braun or to the membranes.

FIG. 207.

Schematic Section of a Primipara in the Last Month (Schroeder).

FIG. 208.

Schematic Section of a Multipara in the Last Month (Schroeder).

During the tenth month the lineæ albicantes, which began to form during the latter part of the second trimester, attain their maximum development. The uterus sinks gradually downward during this period, until the fundus is about 8 cm. below the ensiform process, on a slightly lower level than at the eighth month. At the same time, the inclination of the fundus forward is increased, causing augmented protrusion of the anterior abdominal parietes and pouting outward of the umbilicus. Epigastric flattening is evident; the waist becomes smaller, while the lower abdomen is increased in width. The average circumference of the abdomen in the umbilical region measures 99 cm., midway between the navel and the symphysis, 100 cm.; the average distance from the xiphoid process to the pubes is 45½ cm. The time at which this descent occurs is very variable, even in primiparæ. Under normal conditions it usually takes place about two weeks before labor; sometimes, however, it happens early in the tenth month, and often only a day or two before term. In multiparæ this settling down of the uterus is seldom well marked, since, on account of the relaxed condition of the anterior abdominal wall, the organ does not rise so high, and its inclination forward is increased earlier in pregnancy. In these cases it is sometimes difficult to distinguish between the eighth and tenth months. The diagnosis, however, is cleared up by vaginal examination.

The cause of this phenomenon lies in the engagement of the head covered by the lower uterine segment within the pelvic cavity. The symptoms to which it gives origin are of importance, since they constitute the precursors of labor and indicate a normal pelvis. The woman breathes more fully and easily, and frequently notices a subsidence of the gastric disorders arising during the ninth month. At the same time, there is increased difficulty in locomotion, while vesical and rectal disorders are usually present. The pressure-varices and œdema of the vulva and lower extremities receive a sudden increment. On account of the increased ease in respiration and comparative freedom from digestive disturbances, the result of the descent of the gravid womb, the phenomenon has long been popularly known as "the lightening before labor."

An important functional effect to which the phenomenon just mentioned largely contributes is the so-called acute œdema of pregnancy (Wigand). From eight to fourteen days prior to labor the lower uterine segment becomes very soft and œdematous, while the cervical secretions are greatly increased in quantity, preparatory to the dilatation of the remaining portion of the cervix. One factor in this so-called vital dilatation is undoubtedly the intermittent uterine contractions, as already pointed out. But the suddenness of the œdema and its coincidence with the sinking of the womb render the theory highly probable that the serous exudate is in part a mechanical phenomenon, the result of pressure of the fœtal head upon the neighboring veins. This acute œdema of pregnancy may really be regarded as the beginning of labor, as indicated by Lumpe[1] from the study of fifty primigravidæ.

Diagnosis of the Time of Pregnancy and the Prediction of the Day of Confinement.

The exact diagnosis of the time of pregnancy and the prediction of the day of confinement are impossible, for at least two reasons. The *real* duration of pregnancy is the interval between conception and

[1] *Arch. f. Gyn.*, Bd. xxvi. Hft. 1, p. 42.

labor, but it is absolutely impossible to arrive at the date of conception, since a variable interval of at least one to fourteen days may elapse between insemination and fertilization. Moreover, it is impossible to determine whether the ovum that is fecundated is the one discharged at the menstrual period preceding coition, or the one corresponding to the first menstrual suppression, or one liberated in the menstrual interval.

Then the absolute duration of pregnancy in the human female, as in the lower animals, is variable within wide limits. The *real* duration of pregnancy in the human female is accordingly an unknown quantity.[1] Experience, however, teaches that in woman the *average apparent* duration is ten lunar months, forty weeks, or two hundred and eighty days, from the beginning of the last menstruation. The extreme limits, however, are very wide. Schroeder[2] voices a conviction, fully justified by the professional observation of others, in the following words: "I, myself, do not doubt for one moment that a mature child can be born within 240–320 days of the last period."

According to the law in France (*L'article 315 du Code civil*), "the legitimacy of the infant born 300 days after the dissolution of the marriage is liable (*pourra*) to be contested."

In Austria, the law[3] recognizes the legitimacy of the child born within 240–307 days of the death of the father. A jury of experts give their opinion in cases of alleged protracted gestation beyond 307 days. In America and England "the light of the courts in this matter is reflected light. Physicians must determine the matter; and if the space between the minimum and maximum periods hitherto allowed is shown to be too long or too short, the courts will readily follow the truth as it is made manifest."[4]

In the diagnosis of the time of pregnancy and the prediction of the day of confinement in the concrete case we rely upon the following data:

1. *The Date of Fruitful Coition.*—This datum can seldom be determined. In those rare cases of single coition it is supplied. With us in the United States, especially in the large cities, women are frequently able to fix the time at which methods preventive of conception were not employed. Reckoning 272–275 days from the date of fruitful sexual intercourse, the date of confinement can be predicted with a high degree of probability.

2. *The Date of the Commencement of the Last Menstruation.*—"Unquestionably," says Harvey, "the ordinary term of utero-gestation is that kept in the womb of his mother by our Saviour Christ, of men

[1] See also J. Veit, "Ueber Schwangerschaftsdauer," *Zeitschr. f. Geb. u. Gyn.*, Bd. viii. p. 234.

[2] *Loc. cit.*, p. 85.

[3] *Das k. k. Österreichische bürgerliche Gesetzbuch.*

[4] Wharton: *On Evidence*, sec. 1300.

the most perfect—counting, viz., from the festival of the Annunciation, in the month of March, to the day of the Blessed Nativity, which we celebrate in December. Prudent matrons, calculating after this rule, as long as they note the day of the month in which the catamenia usually appear, are rarely out of their reckoning, but after ten lunar months have elapsed fall in labor, and reap the fruit of their womb the very day on which the catamenia would have appeared had not impregnation taken place." Prof. A. R. Simpson remarks with reference to Harvey's statement, "The dates are derived only from the teachers of the Roman Catholic Church, and when their true meaning is investigated it is found that the 25th of March was held as Lady Day in pagan Rome in honor of Cybele, the mother of the Babylonian Messiah, long before the era of our Lord; while the 25th of December was kept among many Gentile people as the birthday of the son of that 'queen of heaven.'"

In accordance with the notion that the average duration of pregnancy is 280 days from the last menstruation, Naegele[1] devised a ready method of calculating this period from any given date. This method, with slight modifications, has been universally adopted. It consists in counting backward three months from the date of the beginning of the last menstruation, and then adding seven days—in leap-years, after February, six. In February four days, in December and January five days, and in April and September six days only, are necessary to complete the ten lunar months. As women commonly are able to give more accurate information as to the commencement than as to the termination of menstruation, the former date is selected as the starting-point for the computation.

Although, in practice, we rely very largely on this method of the prediction of the day of confinement, the sources of error are numerous and unavoidable. In the more or less periodic morbid discharges of blood from the uterus in early pregnancy and in conception during the amenorrhœa of lactation, disease, and the like, the calculation is impossible. An error in computation of from one to fourteen days, or even greater, earlier or later, is always possible.

3. *The Date of Quickening.*—Quickening is commonly perceived by the pregnant woman about the sixteenth week, or a short time before the middle of pregnancy—a week later in primiparæ than in multiparæ, according to Ahlfeld. But this sensation is experienced in different individuals at widely varying periods, and sometimes is not perceived at all. Entirely apart from the degree of sensitiveness and of attention of the patient, it depends upon the size of the fœtus, the quantity of the liquor amnii, and the like. Still, as a check to other data, the perception by the woman of active fœtal movements is of definite value.

[1] *Lehrb. d. Geb.*, viii. Aufl., p. 122.

4. *The Degree of the Alterations in the Uterus.*—The degree of increase in the size of the uterus, as shown by the position of the fundus, the maximum abdominal circumference, and the distance between the ensiform cartilage and the symphysis pubis, affords an approximate datum of a certain value. Schroeder's measurements have already been quoted. Spiegelberg has arrived at the following average altitudes of the fundus:

From the 22d to the 26th week,	24–24.5 cm.
In the 28th week,	26.7 "
In the 30th week,	28.4 "
From the 32d to the 33d week,	29.5–30 "
In the 34th week,	31 "
" 35th "	31.8 "
" 36th "	32 "
" 37th "	32.8 "
" 38th "	33.1 "
From the 39th to the 40th week,	33.7 "

But the altitude of the fundus and the maximum abdominal circumference are subject to wide variations, dependent upon the condition of the bladder and rectum, the posture of the woman, the engagement of the presenting part, the quantity of the liquor amnii, the thickness of the abdominal parietes, and the like.

5. *The Length and Weight of the Fœtus.*—The determination of the length and weight of the fœtus constitutes one of the best methods in the diagnosis of the time of pregnancy. The individual variations in length and weight at the same period of gestation are relatively unimportant. Of the tables with reference to length and weight compiled by C. Braun, Hecker, Spiegelberg, and Ahlfeld, the first is probably the most reliable.

C. Braun:

5th month,	26 cm.	.5 kilogr.
6th "	31 "	1.60 "
7th "	37 "	1.6 "
8th "	42 "	2.2 "
9th "	47 "	2.8 "
10th "	52 "	3.3 "

Hecker:

35–38 cm.	1170 gr.
39–41 "	1571 "
42–44 "	1942 "
45–47 "	2323 "

Spiegelberg:

7th month,	34.8 cm.	1069 gr.
8th "	38.8 "	1511 "
9th "	45.7 "	2189 "
10th "	. . . .	. . . . .

Ahlfeld:

38.3 cm.	1388 gr.
42.2 "	1880 "
46.9 "	2517 "
49.8 "	3096 "

An approximate estimate of the length and weight of the fœtus can readily be made, upon bimanual exploration, by the expert in abdominal palpation. Indeed, Carl Braun[1] regards this as the best mode of

[1] *Loc. cit.*, p. 120.

determining the time of pregnancy, errors greater than fourteen days being very infrequent in the Vienna clinic, where this plan is almost exclusively relied upon.

Ahlfeld[1] has attempted to determine the length of the so-called fœtal axis by placing one extremity of Baudelocque's callipers upon the cephalic and the other upon the pelvic pole of the fœtal ovoid. The total length of the fœtal body is about twice this distance. In transverse presentations this datum is arrived at by abdominal measurements; in longitudinal presentations it is necessary to introduce one branch within the vagina. Given the total length, the time of gestation is calculated from the tables just mentioned. This method in Ahlfeld's hands has yielded excellent results. Zweifel,[2] Breisky, and others, however, have been less successful in its application. The method is obviously subject to essential sources of error, and it is highly probable that Braun's off-hand rule, practised by an expert in abdominal palpation, affords information just as nearly approaching correctness.

The behavior of the vaginal portion with reference to shortening and softening, to which Tarnier and French observers generally attach so much importance, is of considerable value, especially in primiparæ.

The phenomenon of lightening before labor frequently is of great service in the prediction of the day of confinement, although never of decisive value.

The Diagnosis of Multiple Pregnancy.

The only form of multiple pregnancy capable of positive diagnosis is that of twins. Among the probable signs worthy of special mention are the enlargement of the abdomen—greater than in correspondence with the time of gestation—with the tendency to the preponderance of the transverse over the vertical diameters; the appearance of a longitudinal furrow; the sensation of unusually active fœtal movements in all regions of the uterus; the elevation of the lower uterine segment and the absence of a presenting part; the exaggeration of all the pressure disorders of gestation, in particular the varices and œdema of the vulva and lower extremities. Of all of these symptoms, the most important is the unusual size and shape of the abdominal enlargement. The longitudinal furrow is commonly absent in multiple pregnancy, while it is frequently present in simple gestation, usually indicating the embryonal origin of the uterus out of the two halves.

The positive diagnosis depends upon signs elicited by abdominal palpation, auscultation, mensuration, and the vaginal touch.

[1] *Arch. f. Gyn.*, Bd. ii. p. 354: "Berichte u. Arbeiten aus der Klinik zu Giessen."
[2] *Ibid.*, Bd. xxii. Heft 3, p. 491.

Budin[1] has called attention to the relative positions of the ova. Three chief types are observed. The fœtuses lie laterally, one on each side of the uterus, or one lies above, the other below, or one in front of the other. One egg may retain its nearly round outline, while the other is drawn out so as to cause its more or less complete envelopment. Under favorable conditions palpation reveals the exact presentations of the two children, or more than two large portions of the fœtal body, or a large number of upper and lower extremities. Two large portions of the fœtal body may be detected by abdominal palpation, while a third is felt *per vaginam* engaged within the pelvic inlet. One fœtus may be recognized by palpation as presenting in the first position of the vertex, while heart-tones may be heard above the umbilicus to the right of the median line.

By auscultation alone it is frequently possible to detect two areas, diametrically opposite, over which two sets of fœtal heart-tones are heard with maximum intensity. If the frequency of the heart-beats over these two areas is different, and if the transmitted maternal heart-tones can be excluded, the diagnosis is established.

In exceptional cases the vaginal touch may detect rapidly-successive presentations of the cephalic and pelvic poles of the fœtal ovoid. Depaul in two cases detected a furrow dividing the bag of waters into two parts, indicating the presence of at least two amnions.

Ahlfeld in particular has demonstrated the value of menstruation in the diagnosis of twin pregnancy. If the distance between the large part presenting and the large part at the highest point in the fundus uteri—that is, the length of the fœtal axis—is greater than 30 cm., the presumption is that the two parts belong to different fœtuses.

The Diagnosis of Primiparity and Multiparity.

The questions as to whether a woman has ever been pregnant, whether she is pregnant for the first time, or has already borne children, are of great medico-legal consequence. In the majority of cases pregnancy and labor leave indelible traces in the changes of the vaginal portion, vagina, hymen, vulvar orifice, the relaxed abdominal walls, the lineæ albicantes, and in the alterations of the mammæ, so that a positive diagnosis is possible.[2] Under certain conditions, however, the woman may have repeatedly borne children without the persistence of any objective changes upon which even a probable diagnosis can be established. The vaginal portion may, after the lapse of years, undergo such a degree of involution that it closely simulates the virgin organ. On the other hand, the cervix of the virgin may become the seat of morbid processes and present many of the appearances of the organ in

[1] *Loc. cit.*, chs. xxx.-xxxv.

[2] Carl Braun: *loc. cit.*, p. 125.

the multipara. The objective changes measurably characteristic respectively of primiparity and multiparity have already been incidentally mentioned, and are fully considered in other sections of this work.

The Diagnosis of the Life or Death of the Fœtus.

In the perfectly healthy pregnant woman, in the absence of any special ground for a supposition to the contrary, the presumption is that the child is alive. The perception of the fœtal heart-tones, active fœtal movements, and, to a certain degree, the elasticity of the fœtal body upon palpation, render the diagnosis positive.

On the other hand, the death of the fœtus during pregnancy can only be diagnosticated with a greater or less degree of probability. The complete disappearance, sudden or gradual, of the fœtal heart-tones, the cessation of active fœtal movements, the loss of elasticity by the fœtal body, the persistence of the fœtal extremities in the positions in which they have been artificially placed, are signs presumptive of death. The fact that the mother no longer perceives fœtal movements is almost devoid of diagnostic import, since whenever uterine contractions occur the mother commonly ceases to feel such movements. Nor is the sensation of quickening diagnostic of the life of the child, for reasons already mentioned. The progressive loss in maternal weight, especially during the last three months, in the absence of any other adequate cause has been shown by Gassner to be a symptom of great value. The existence of maternal diseases—*e. g.* syphilis, which often causes fœtal death—the cessation of growth or shrinkage in the volume of the uterus and of the breasts, the maternal sensations of weight in the lower abdomen, chilliness, languor, loss of appetite, yield evidence only of a probable nature.

Schroeder[1] has shown that the fœtus is a source of heat to the uterus, and on this account the uterine temperature is normally higher than that of the vagina. This difference ceases when the fœtus dies. Cohnstein[2] and Fehling[3] have proposed to utilize this fact in the diagnosis of the life and death of the fœtus. They found in a limited number of cases that when the vaginal and uterine temperatures were the same, the fœtus was dead.

The evidence collected from all these sources is very seldom sufficient to warrant the artificial evacuation of the contents of the uterine cavity under the sole indication of the death and retention of the fœtus within the cavum uteri. In exceptional cases the finger introduced through the patulous cervical canal may detect changes in the consistence of

[1] *Virchow's Archiv*, Bd. xxxv.
[2] *Arch. f. Gyn.*, Bd. iv. p. 547; *Virchow's Arch.*, Bd. lxii. p. 141.
[3] *Arch. f. Gyn.*, Bd. vii. p. 143.

the fœtal head and the loosening of the articulations of the cranial bones which, in connection with the signs already mentioned, justify the induction of premature labor.

The Hygiene of Pregnancy.

While pregnancy is an essentially physiological condition, still the alterations in structure and function are so numerous and so profound that attention merely to the laws of general hygiene governing conduct in the non-gravid state is entirely insufficient. It is necessary that the pregnant woman shall regulate her daily life in strict accordance with the great change in most of her relationships. The observance, however, of the dictates of a rational hygiene peculiar to the state of pregnancy does not ordinarily involve a radical change in all of the woman's former habits, so long as they are not inimical to her new condition. The hygiene of pregnancy may be briefly discussed under the following topics: food and drink, clothing, bathing, air, exercise, sleep, rest, mental condition, care of the breasts, examination of the urine, the presentation and position of the fœtus, and the pelvis.

Food and Drink.—The dietary should consist of a good, generous supply of proteids, fats, amyloids, salts—fresh meats, vegetables, fruit—and water. Normally, the appetite is increased after the cessation of morning sickness, the woman consuming food for two. The evening meal should always be light, and highly-spiced articles of food ought to be avoided. Within physiological limits the whims and caprices of the appetite may be humored. Milk, coffee, tea, light wines, and beer are consumed according to the woman's previous habits. It is well to exercise caution in the use of alcoholic liquors, on account of the extreme ease with which the alcoholic habit is acquired during gestation by women of all classes.

Meigs was very successful in the palliative treatment of the nausea and morning sickness of pregnancy by having his patients take a light breakfast early in the morning an hour or two before rising. A cup of coffee with a bit of toast was brought to the bedside at the earliest morning hour. The patient, suddenly awakened, took this breakfast without rising, and then fell asleep again.

Daily evacuations of the intestinal tract are secured by voluntary efforts at defecation at a fixed hour, without respect to desire, and occasional enemata of cold water. The diet, selected with reference to this end, consists largely of oatmeal porridge, brown bread, peeled ripe fruits, and the vegetable oils. Constipation is to be especially avoided during the last three months.

Clothing.—The clothing should be such as to protect the person from cold and at the same time not to interfere with the development of the uterus and breasts nor to compress the vessels of the lower extremities. Parvin[1] points out that the word *enceinte* means, in Latin, ungirdled or without a girdle, in commemoration "of the custom of Roman women, who, when they became pregnant, laid aside their girdle, the *fascia mammillaris*." Corsets are now obtainable specially adapted to pregnancy, so as not to compress the nipples nor interfere with the growth of the uterus and mammary glands. The clothing should be suspended, as far as possible, from the shoulders, and circular garters ought not to be worn. Pregnant women ought always to wear drawers in summer as well as in winter. Stockings must be warm, and the shoes large and with broad, low heels. In multiparæ with relaxed abdominal walls a neatly-fitting binder affords comfort and preserves the normal forward inclination of the womb.

Bathing.—The functional activity of the skin must be carefully maintained throughout pregnancy, and the most effective method to secure this end is the habit of frequent bathing—that is to say, daily or two or three times in the week, according to the custom of the individual—in water neither hot nor cold. Bathing in hot or cold water and sea-bathing ought to be forbidden, on account of the excitation of the vascular and nervous systems. The daily vaginal douche with tepid water is destitute of harm, while sitz-baths and foot-baths must be proscribed.

Air, Exercise, Sleep, Rest.—Up to the third month and during the last weeks of gestation the pregnant woman is usually indisposed to physical exertion—in the one case by morning sickness, and in the other by the increased difficulty in locomotion. In the interval, however, exercise in the open air, such as walking, to the point of slight fatigue, is of great benefit to the physical well-being of herself and the fœtus. Dancing, riding, swimming, driving over rough roads, lifting heavy weights, and the like are obviously dangerous experiments. Railway travel in comfortable cars, through limited distances, can ordinarily be permitted from the third to the eighth month; travel by water must be absolutely interdicted, the especial danger arising from sea-sickness.

The pregnant woman requires more sleep than is strictly necessary in the non-gravid state: from nine to ten hours may be accepted as an average period.

With respect to sexual intercourse during gestation, it is necessary to give advice with an extreme degree of circumspection. The physician's counsel is not often requested, and when gratuitously offered it is still more seldom acted upon.[2] During the first three months and the latter weeks of gestation it is wiser for husband and wife to occupy different beds, as the danger of abortion or premature labor is considerable. In any case in which the tendency to abortion is at all evident sexual intercourse must be forbidden throughout pregnancy. During the interval

[1] *Loc. cit.*, 211. [2] Spiegelberg remarks, "It is preaching in the wilderness."

between the end of the third month and the latter weeks of pregnancy, in perfectly healthy women, contact ought to depend upon the desire of the female, which, as a matter of fact, it commonly does. Roederer speaks of the *viri fastidium*, Stoltz of the *horreur du mari*, sometimes evinced by the pregnant woman. On the other hand, the weight of opinion is very much in favor of the view that in the majority of healthy pregnant women desire is greatly increased, even to the point of nymphomania. A reversal of the so-called classical posture may be suggested with perfect sobriety.

Mental Condition.—In view of the increased emotional susceptibility and frequent tendency to despondency, the mental condition of the pregnant woman demands a certain degree of attention. Presence at church, the theatre, or other places where large numbers of people are congregated is unwise, on account of the mental impression, if for no other reason. It is the physician's privilege to dispel many of the popular illusions which needlessly harass the pregnant woman by counsel and the recommendation of suitable reading. Fright, bodily violence, and the like may produce structural alterations in the egg, as the effect of hemorrhage, partial rupture of the membranes, partial loss of their contents, resulting sometimes in the production of monstrosities; but the direct influence of the mother on the moral and intellectual development of the fœtus in utero, in the absence of any such coarse physical cause, is a matter of the purest speculation.

Care of the Breasts.—The mammary glands must be freed from all compression and warmly covered. The nipples require more particular attention. They must be kept perfectly clean by daily washings with simple water; occasionally soap may be employed. It is a good plan during the last six weeks of gestation to bathe the nipple daily with cologne-water, tincture of benzoin, tincture of arnica, or alcohol and water. The epithelium covering the organ is stimulated and rendered less sensitive, but it is not converted into leather, as when tannin is employed. All pressure must be removed; to effect this it is seldom necessary to use nipple-shields. All manipulations of the nipple to aid in its elongation are not only useless, but positively harmful, on account of the danger of provoking uterine contractions. Recent researches into the etiology of puerperal mastitis indicate that the large proportion of mammary abscesses during the puerperium are due to the septic infection of some crack or fissure in the nipple. The prophylaxis should begin during pregnancy. Absorbent cotton or disinfected linen or gauze only should come into direct contact with the nipple.

The Examination of the Urine.—It is the duty of the physician to test the urine for albumen, especially during the last three months of pregnancy, at such periodic intervals as the conditions of the concrete case may determine.

Examination of the Presentation and Position of the Fœtus and the Pelvis.—It is also the duty of the medical attendant to determine the presentation and position of the fœtus during the latter weeks of gestation—during the thirty-second week in primiparæ, during the thirty-sixth week in multiparæ. The importance of this examination is obvious. If an abnormal presentation is present, it is usually possible to effect its transformation into a normal presentation before the advent of labor. Abdominal palpation is amply sufficient to reveal the facts desired.

It is not always necessary, nor is it always expedient, to insist upon an elaborate investigation of the dimensions of the pelvis. In the United States there exists the very decided presumption that the native-born woman has a normal pelvis. If, however, for any reason, there is cause to believe that some pelvic deformity exists, it becomes necessary to make a thorough examination at this time with reference to the possible induction of premature labor. In multiparæ the history of former labors will usually disclose the presence or absence of pelvic deformity; in primiparæ the engagement of the presenting part is presumptive of a normal pelvis.

PATHOLOGY OF PREGNANCY.

The pregnant woman is liable to many disorders which can be directly traced to her new condition. These disorders are, for the most part, pathological exaggerations of physiological processes. Then pregnancy confers upon the individual no immunity from the diseases to which the non-pregnant woman is liable. But certain acute and chronic diseases sustaining the relation of accidental complications are variously modified as to their clinical course by pregnancy, and in turn variously influence the nature of gestation. Accordingly, the general disorders of pregnancy affecting the maternal organism may be divided into two classes: I. The Pathological Exaggerations of Physiological Processes; and II. The Peculiarities of Certain Accidental Acute and Chronic Diseases occurring in the Course of Pregnancy.

I. THE PATHOLOGICAL EXAGGERATIONS OF PHYSIOLOGICAL PROCESSES.

It is always difficult and frequently impossible to draw the boundary-line at which normal functional activity becomes morbid. As remarked by Spiegelberg, all the diagnostic penetration of the physician is demanded to recognize this transition. Then, a high exercise of judgment is necessary to determine when to preserve a wise and masterly inactivity, when to adopt measures of active interference.

ALTERATIONS IN THE CONSTITUTION OF THE BLOOD.

Chlorosis and Hydræmia.—The red corpuscles, albumen, and iron of the blood are normally diminished, especially during the second half of pregnancy, while the white corpuscles and fibrin receive an increment. When the number of red corpuscles is morbidly diminished, the woman becomes chlorotic. In this condition the diminution is less in the number than in the amount of hæmoglobin contained in the individual corpuscle. The color-value of each globule is lessened, and hence the peculiar yellow-green complexion from which the condition derives its name. If in addition to these changes the amount of albumen undergoes pathological diminution, hydræmia ensues. Chlorosis and hydræmia can only be regarded as independent affections in the absence of cardiac and renal lesions. Commonly, individual predisposition to impoverishment of the blood exists in marked cases. Insufficient food and bad hygienic surroundings suffice to develop this latent tendency.

Effusions into the subcutaneous connective tissue, the thoracic and abdominal cavities, are liable to occur. Sudden exudations into the pleuræ and pericardium are especially dangerous, since they often take place without sufficient symptoms to attract the woman's attention to her serious condition. The œdema of the vulva, lower abdomen, and lower extremities, sometimes actually impeding locomotion, is an annoying complication.

The relation of chlorosis and hydræmia to hydrorrhœa gravidarum and hydramnion is fully discussed in another article. It may be said, however, in passing, that the causative nature of this relation is fully established in certain cases.

Chlorosis and hydræmia have an important influence in the causation of abortion and premature labor through immediate action upon the fœtus or indirectly through the predisposition to morbid conditions of the decidua or fœtal envelopes. The various forms of simple anæmia are also of considerable prognostic moment when parturition is attended by any unusual loss of blood. In cases of the so-called habit of abortion these conditions rank only second to syphilis in the list of causative agencies.

Œdema of the face and upper extremities is rare. The urine is increased as to its water, and occasionally contains traces of albumen in the absence of kidney disease.

TREATMENT.—The indications for treatment are the improvement of the quality of the blood, the elimination of the superfluous water, and the alleviation of the local œdema. Nutritious food, and iron in combination with non-irritant diuretics, fulfil the first two indications. Bland's pill (Pulv. ferri sulphat. exsiccat., Potass. carb. puræ, āā ℥ij; Syrupi q. s., ut ft. mas. div. in pil. No. xlviij) and Basham's mixture—Mistura ferri et ammonii acetatis, U. S.—are eligible preparations.

Progressive Pernicious Anæmia.—Gusserow[1] in 1871 clearly described a peculiar form of progressive pernicious anæmia incident to pregnancy, although Lebert mentions fatal cases of the chlorosis of pregnancy as early as 1853. The disease is of rare occurrence; Gusserow observed 5 cases in an interval of two years (1868–70) in Zürich, while Batut (1879)[2] was only able to collect 10 authentic cases; Graefe (1880),[3] 25.

Etiology.—Gusserow's cases occurred in comparatively young women, twenty-four to thirty-six years old, four being multiparæ. All were in apparently perfect health before pregnancy. A high degree of anæmia developed chiefly during the second half of gestation without evident cause, resulting in the expulsion of the fœtus about the eighth month and in death soon afterward. Endemic influences, insufficient food, hemorrhages, and all the usual causes of anæmia were carefully excluded. The rapid progress of the disease with the advance of pregnancy also favors the assumption that this form of anæmia is a pathological exaggeration of the serous plethora incident to gestation. It is altogether probable that pregnancies succeeding each other at brief intervals exercise a predisposing influence: in 4 of the cases cited 6 children were born in nine years, 7 in twelve years, and 9 in ten years.

Morbid Anatomy.—Post-mortem examination reveals the alterations due to anæmia, hydræmia, and their sequelæ—anæmia of the brain and its membranes, effusions into the various serous cavities of the body, occasional fatty degeneration of the myocardium and blood-vessel walls, and retinal hemorrhages. The number of white blood-corpuscles is not abnormally increased, and all signs of leukæmia—splenic tumor, swelling of the lymphatic glands, and changes in the other organs of the blood-glandular system—are entirely wanting. The condition is that of oligæmia or oligocythosis.

Symptoms.—The prodromal symptoms appear during the first half of pregnancy, are obscure, and cannot be distinguished from the effects of chlorosis and hydræmia. During the second half of pregnancy abortion or premature labor occurs spontaneously. The fœtus is commonly stillborn or dies within a few hours of birth. The muscular exertion and loss of blood consequent upon parturition usually precipitate the lethal issue in the case of the mother.

Prognosis.—All of the 5 cases reported by Gusserow terminated

[1] *Arch. f. Gyn.*, Bd. ii. p. 218.
[2] *Thèse de Paris.*
[3] *Diss. In., Halle.*

fatally. Out of the 25 cases collected by Graefe, 1 recovered, 2 were discharged as improved, the others died before or shortly after labor.

TREATMENT.—As food, iron, and other tonics have little or no effect upon the disease after it has passed its incipient stages, therapeutic resources are limited. Negative results have followed all attempts at transfusion. This operation, however, has been commonly performed very late in the course of the disease. With more perfect methods and greater experience transfusion at an early period is certainly worthy of more extended trial.

Gusserow, Gfoerer, and others recommend the artificial induction of abortion or premature labor. In the three cases recorded by Graefe in which the patients survived pregnancy the evacuation of the uterine contents apparently exercised a favorable influence upon the condition of the blood. To be of decisive value, the cavity of the uterus must be evacuated early in the course of the disease, as, when once fully established, the prognosis is quite as unfavorable in the non-gravid as in the pregnant woman (Biermer, Immermann).

Hæmophilia.—Kehrer[1] clearly describes three cases of hæmophilia occurring during pregnancy which are of peculiar interest, inasmuch as they throw some light on the pathology of this obscure disorder. The salient features of these cases are, very briefly—

CASE I.—Fr. H——ch, from Giessen, twenty-eight years old, small, slender, fresh-appearing laborer's wife. Epistaxis during youth. First pregnancy and labor normal. During second pregnancy severe uterine hemorrhages and nose-bleedings, once hæmatemesis. Induction of abortion at the end of the eighth week on account of the increasing anæmia. After both abortions speedy cessation of the hemorrhages. During the succeeding two years no repetition of the hemorrhages, and the patient was apparently in a normal condition.

CASE II.—Frau M——s, large, well-formed, pallid woman, twenty-three years old. Three abortions, with profuse hemorrhage, within the first three years of her marriage. During the fourth pregnancy frequent severe nose-bleedings; in the fourth month continuous hæmaturia, then epistaxis. Premature labor at the beginning of the eighth month. Death from anæmia one month later.

CASE III.—Fr. F——k, from Giessen, large, slender, well-nourished, pale blond, twenty-seven years old. Epistaxis during youth, profuse menstruation. In the second half of the third pregnancy profuse nose-bleeding until term. During the puerperium either nose-bleeding or metrorrhagia; numerous sudden gushes of blood from the uterus. Death, two months after labor, from anæmia.

ETIOLOGY.—In these, as in the majority of cases recorded, the disposition to hemorrhage was hereditary. The diathesis is transmitted

[1] "Die Hæmophilie beim weiblichen Geschlechte," *Arch. f. Gyn.*, Bd. x. p. 201.

through the male line. Atavism by transmission is commonly observed in the female. The daughters of a "bleeder," while remaining apparently healthy themselves, are apt to transmit the disposition to their male offspring, and the diathesis may extend through four or five generations. The old observation, that "bleeder" families are remarkably fertile, has been abundantly confirmed. Pregnancy exerts decided influence in the development of hæmophilia. In all the cases related by Kehrer there was a longer or shorter interval of complete freedom from bleeding before conception. During the continuance of gestation the disposition to hemorrhage increased constantly and rapidly. With the cessation of pregnancy in Case I. the tendency again sank into abeyance. The disease assumes a severer type in the multipara than in the primipara. In Case I. the first pregnancy and labor were perfectly normal. In Cases II. and III. the diathesis, leading to death, was developed respectively during the fourth and third pregnancies.

PATHOLOGY.—Two factors are usually present in hæmophilia in the male and the non-gravid female—congenital fragility of the vessels and defective coagulability of the blood.[1] But in Kehrer's cases, especially in Nos. I. and II., the blood from the nose and the uterus coagulated in a perfectly normal manner, and no important quantitative or qualitative changes were observed. In favor of the view that in these cases, at least, the hæmophilia was due to structural changes in the blood-vessel walls, the following facts may be mentioned: the great disproportion between the cause and the effect, the long duration of the hemorrhage in spite of the employment of styptics and other measures, and the changeable locality of the bleeding. Changes in the joints, so frequently observed in male bleeders, were notably absent.

DIAGNOSIS.—Pernicious anæmia, leukæmia, and scorbutus can usually be excluded by the absence of their measurably characteristic symptoms. The fact of heredity, the history of epistaxis, hæmatemesis, purpura, vicarious and other menstrual anomalies during youth, and the general behavior of the bleedings, render the recognition of the disorder comparatively easy.

PROGNOSIS.—The outlook with reference to the mother and child is obviously very serious, and its gravity increases with the duration of pregnancy.

TREATMENT.—Women of the hemorrhagic diathesis ought not to marry nor bear children. If they themselves are not bleeders, they

[1] Klebs and certain other pathologists assert that the changes in the constitution of the blood in hæmophilia are relatively insignificant, but that the essential morbid condition is structural changes in the blood-vessel walls. Klebs defines hæmophilia as a parablastic, hereditary disturbance, in which only one portion of the connective-tissue blastema is affected—namely, the blood-vessel system (*Allgemeine Pathologie, etc.*, Jena, 1887, Theil i. p. 28).

usually transmit the disposition to their male offspring. The same rule ought to govern the conduct of male bleeders.

Pregnant women, the subjects of hæmophilia, seldom die during the first bleeding, so that there is commonly ample time to carefully weigh all the facts in the concrete case before resorting to radical measures of treatment. The diet should be bland and non-irritant, inasmuch as a relatively insignificant elevation of blood-pressure may cause the renewal of the bleeding. Indeed, all the hygienic conditions of the case must be regulated with this fact clearly in view. The local arrest of hemorrhage is best effected by graduated mechanical pressure, styptics being of only palliative value. In metrorrhagia the vaginal tamponade is the only reliable measure. Iron and the long list of remedies of such undoubted worth in simple anæmia and allied disorders are absolutely valueless in the condition under consideration.

The objective point of all the preparatory treatment here indicated is the artificial evacuation of the uterine contents—abortion or premature labor—at the earliest moment the conditions of the concrete case will permit. This operation, to offer a reasonable prospect of recovery, must be performed before a serious degree of anæmia has resulted from the bleeding. Otherwise, it merely precipitates the lethal issue. All precautions must be taken to prevent post-partum hemorrhage—a frequent and usually a fatal sequela.

Plethora.—The experiments of Spiegelberg and Gscheidlen, already mentioned, prove the possibility of the occurrence of so-called arterial plethora during pregnancy, notwithstanding the fact that in recent pathology general and persistent polyæmia plays a very subordinate rôle. Actual increase in the red corpuscles, albumen, iron, and total blood-mass is sometimes observed during the second half of pregnancy under the most favorable conditions respecting the individual and the environment. Still less frequently does this state of the blood give origin to unpleasant symptoms. Occasionally, however, cases are observed in which various local congestions are best explained upon this hypothesis. The symptoms are—congestions of the head and mammæ, palpitations, tendency to vertigo, disturbances of the portal circulation, and hepatic torpor, constipation.

The indications for TREATMENT are met by restricted diet, muscular exercise, and an occasional saline purge. Spiegelberg recommends bleeding in selected cases, as frequently practised by country practitioners.

Circulatory Disturbances.

Œdema and Varices.—Among the circulatory disturbances incident to pregnancy, the mechanical œdema and varices of the vulva, rectum, and lower extremities deserve attention.

Varices occur in pregnancy in the proportion of 20–30 per centum, according to Budin;[1] in 21 per centum, according to Cazin.[2] They are more distinct, but not more frequent, in multiparæ than in primiparæ.

The qualitative and quantitative changes in the blood and individual differences in the tonus of the blood-vessel walls are the important predisposing factors. Early in pregnancy, before considerable enlargement of the uterus, these phenomena are caused by a slowing of the blood-current in the veins of the lower extremities, resulting from the dilatation of the pelvic veins. Later, the constantly-increasing intra-abdominal pressure, corresponding with the augmentation of uterine volume to which the inferior vena cava is exposed throughout nearly its entire course, is the important determining agent. During the last weeks the head and lower uterine segment, engaged within the pelvic cavity, directly compress the iliac veins.

As the force and frequency of the intermittent uterine contractions increase, a new etiological factor makes its appearance. During the systole of the uterus the blood is squeezed out of the uterine walls and the maternal placenta into the extra-uterine blood-vessels. The longer the duration and the greater the force of each contraction, the profounder is the degree of anæmia. During the beginning of the systole the quantity of blood in the extra-uterine venous channels is increased, while the advent of arterial blood is retarded.[3] At the acme, even a backward current in the arteries is produced when the intra-uterine pressure is greater than the pressure in the maternal sinuses.

Posture exercises a decided influence. Women who preserve the erect attitude and work during pregnancy are much more subject to œdema and varices than those who spend the greater portion of the period in the recumbent position.

The mechanical œdema of pregnancy is restricted to the subcutaneous connective tissue of the lower abdomen, the vulva, and the lower extremities, becoming most pronounced during the latter months, but never attaining the proportions of the anasarca of hydræmia or of Bright's disease. During the night, while the patient is lying in the horizontal position, it commonly disappears.

Active measures for the relief of the symptoms are seldom indicated. Threatened gangrene of the skin from hyperdistension, however, may render puncture of the hydropsical regions necessary. It is quite possible to interrupt pregnancy by this little operation, especially if the labia are punctured. Elevation of the lower extremities, rest in the dorsal decubitus, local hot-water packs, mild diuretics, elastic bandages and stockings, commonly fulfil all indications for treatment.

[1] "Des Varices chez la Femme enceinte," *Thèse d'Agrégation*. Paris, 1880.

[2] *Archives de Tocologie*, 1880-81.

[3] Lahs: *Loc. cit.*, p. 87.

Varices of the vulva seldom give origin to serious symptoms during pregnancy, but are of considerable clinical significance during labor. Spiegelberg[1] records one death from hemorrhage in a VI.-para in the ninth month, the bleeding occurring from a varix in the right labium. The rupture is seldom spontaneous—commonly the result of trauma, as the patient's scratching to relieve the itching to which a varicose part is subject. The formation of thrombi, inflammation, suppuration, and the process of embolism are possible, though rare, complications.

Hemorrhoids, of relatively frequent occurrence during pregnancy, are observed more often during the puerperium. As a rule, varices of the anus and lower portion of the rectum in the pregnant woman are due to constipation and the straining efforts during the act of defecation. Probably in the majority of cases the condition is in existence prior to pregnancy. Direct interference with the return of the venous blood from the inferior portion of the rectum by the uterus is observed only during the first trimester and after the engagement within the pelvic cavity of the head and lower uterine segment. Although causing unpleasant symptoms during pregnancy, their chief clinical significance commences with labor and the puerperium. Occasionally, hemorrhoids during gestation are the site of alarming hemorrhage and the point of departure of anal fissures and fistulæ (Verneuil).

The superficial varices of the lower extremities are only the consequences and manifestations of the same condition in the deep-lying veins. Frequently they are capillary, and form blue networks around the malleoli and to the inner surfaces of the thighs. The internal and external saphenous veins are commonly involved. Large congeries of dilated veins are found over the inner sides of the thighs, usually above the knees. Fatal hemorrhage during pregnancy is a rare phenomenon. Spiegelberg, however, records three cases of this character: Case No. I., VII.-para, in the eighth month, femoral varix; Case No. II., I.-para, in the twenty-fourth week, varix on the posterior aspect of the upper third of the right thigh; Case No. III., I.-para, in the twenty-fourth week, near term, varix on the inner surface of the left thigh in the vicinity of the knee. Phlebitis and the processes of thrombosis and embolism are of obvious significance even when the loss of blood is trivial. The rupture of the vein under these conditions is usually the result of trauma, although Bryant[2] records a case of spontaneous laceration of the internal saphena, with the formation of a thrombus on the inner surface of the thigh.

Treatment.—The preventive treatment of the hemorrhoids of pregnancy, labor, and the puerperium consists largely in the treatment of constipation, securing regular and gentle evacuation of the bowels.

[1] *Loc. cit.*, p. 235.

[2] *Med. Times and Gazette*, 1850.

Fordyce Barker[1] has called attention to the great value of aloes in the treatment of piles occurring during pregnancy. He states that Oppolzer was especially renowned for his skill in the treatment of this condition. For piles associated with constipation he used aloes and quinine; without constipation, aloes and sulphate of iron. For bleeding hemorrhoids he suggested the following formula: R. Ferri sulphatis, gr. xx; Ext. aloës aq., ℥j; Ext. taraxaci, q. s. Ft. pil. No. 60. S.—One pill morning and evening, and increase to three a day if necessary. Large purgative doses of aloes, however, must be avoided during pregnancy, on account of the marked influence of the drug upon the pelvic circulation. Frequent hot fomentations in connection with anodyne and astringent ointments will relieve the pain from congestion of the hemorrhoids. Iodoform, applied in solution or in substance as a suppository, is an efficient local anæsthetic. It is even asserted that this drug "will so benumb the parts that defecation may take place without the person or animal being aware of it."[2] All operative interference for the purpose of effecting a radical cure is strongly contraindicated, on account of the extreme danger of interrupting pregnancy. Even attempts at reduction must be instituted with extreme care.

Elevation of the lower extremities and equable compression by an elastic bandage or rubber stocking palliate the symptoms caused by varices of the lower extremities. P. Ruge,[3] A. Martin, Vogt, and others have observed favorable results in severe cases from the hypodermic injection of ergotin; Englisch, from the injection of equal parts of alcohol and water. The injection is made into the connective tissue beneath the varix. It is seldom necessary, however, to resort to such radical measures, as the condition usually disappears during the puerperium.

In the event of rupture of a varix the wound is treated in accordance with the well-known principles of antiseptic surgery.

Simple Goitre.—The physiological hypertrophy of the thyroid gland at puberty and during pregnancy has been already mentioned. The exaggeration of this normal enlargement to such a degree as to be productive of serious symptoms is not an infrequent disorder of pregnancy.

ETIOLOGY.—The causation of the bronchocele occurring in pregnancy is very obscure. The hereditary character of goitre in these cases has been frequently asserted, although never clearly established. The disease is certainly not endemic.

A number of facts, fully supported by abundant clinical observation, render the theory almost certain that some necessary relation exists between pregnancy and certain cases of simple goitre. The disease is

[1] *American Practitioner*, 1872.

[2] H. C. Wood: *Therapeutics, etc.*, 6th ed., 1887, p. 446.

[3] *Berl. Beitr. z. Geb. u. Gyn.*, Bd. iii. p. 7.

very much more common in women than in men.[1] The intimate relation between menstruation and menstrual disorders and the thyroid is fully established.[2] The same connection between this gland and functional and organic disorders of the uterus and ovaries has been observed. The disease is observed much more frequently in women who have borne children than in sterile married women.[3] Bronchocele often makes its first appearance during pregnancy, increases rapidly in size during this period, and subsequently becomes reduced in volume. These facts indicate that whatever the true causes of simple goitre may be, pregnancy is often the actual exciting and determining cause.

PATHOLOGY.—The pathology of simple goitre in pregnancy is largely a matter of speculation. Poincaré[4] points out the great richness of the gland in nervous filaments of all sizes, out of proportion to the number of blood-vessels, and is of the opinion that the close relationship between the thyroid and the generative organs is of a sensory nature. Sloan believes the pregnant womb exerts a determining influence in the development of bronchocele "through the sympathetic nervous system, from the inferior and middle cervical ganglion of which its main nerve-supply is derived." Laycock[5] asserts that in "90 per centum of ordinary cases it is the ovaria which have this influence."

The condition has been ascribed to the increased force of the heart's action during pregnancy—an untenable hypothesis. Kocher's experiments seem to indicate that the thyroid may secrete a substance necessary to the nutriment of the brain, and that its size in pregnancy is due to increased functional activity. Finally, it is alleged that the thyroid, as a member of the blood-glandular system, is actively involved in the blood-changes incident to pregnancy.

MORBID ANATOMY.—Wölfler has carefully examined the numerous thyroids extirpated by Billroth, many of which were directly traceable to pregnancy. He found that apart from the tumors of struma cystica, the large proportion of specimens were examples of pure adenomata or cysto-adenomata. The tissue showed widely different degrees of consistence—sometimes foci of secondary metamorphoses. Cystic degeneration, blood-extravasations the result of amyloid degeneration of the blood-vessel walls, fatty degeneration and caseation with the deposition of crystals of cholesterin, and calcification, are among the more important secondary changes.

Sometimes the goitre becomes the seat of active inflammation with abscess formation, as in the cases described by Dolbeau and Charpentier.

[1] Laycock: in 26 men out of 551 cases.

[2] Lawson Tait: *Obstet. Journ.*, 1875; E. W. Jenks: "The Relations of Goitre to Pregnancy and Derangements of the Generative Organs of Women," *Am. Journ. of Obstet.*, 1881.

[3] Allen Thompson Sloan: *Edin. Med. Journ.*, September, 1886, p. 207.

[4] Robin's *Journal de l'Anatomie.*

[5] *Lecture on the Goitrous Diathesis.*

CLINICAL COURSE.—The thyroid gland, first becoming prominent at puberty, remains stationary until pregnancy supervenes. During the first or second pregnancy the gland increases rapidly in size, but seldom giving rise to symptoms of severe dyspnœa. In the interval between labor and the succeeding pregnancy the tumor is reduced in size, but remains a little larger than it was before pregnancy. With the succeeding gestation it grows more rapidly, frequently attaining enormous proportions, threatening death from asphyxia, only to be reduced again in volume after labor. This process continues with each successive pregnancy, provided the woman does not succumb to the mechanical interference with respiration, until the menopause, when the tumor diminishes greatly in size or in rare cases entirely disappears.

The enlargement begins in one lobe, and subsequently becomes symmetrical. When one lobe only is involved, the trachea is frequently dislodged from its normal relations. A great increase in the size of the tumor is not always essential to the production of dangerous asphyxia. When the tumor develops behind the trachea or in the substernal region, a relatively slight increase in volume is sufficient to seriously compress the windpipe.

Sudden death from asphyxia may result, as pointed out by Rose,[1] from the softening of the tracheal cartilages and pressure-atrophy effected by the presence of the tumor. Under these conditions the trachea is reduced to a membranous tube, and the sudden turning of the head to one side is sometimes sufficient to occlude its lumen. Béclard and J. Colquet have recorded cases in which sudden asphyxia was developed during labor as the result of rupture of the blood-vessels within the parenchyma of the organ.

Charles Caldwell[2] has recently reported a case of goitre complicating pregnancy, which also came under the writer's observation: Fr. G——, born in Königsberg in 1852, vigorous, healthy woman, of medium stature and great muscular development. No history of goitre in her family, and the disease not endemic in the region of her birth. Patient was married in 1872, and has borne ten children. No enlargement of the thyroid was noticed before marriage nor during her first four pregnancies, the terminations of which were perfectly normal. These children were born in Germany, the others, six, in the United States during the last nine years. During the fifth pregnancy the left lobe of the thyroid began to grow larger, but did not occasion any distress. The lobe gained permanently in size during the sixth and seventh pregnancies, but was productive of neither pain nor dyspnœa; normal deliveries. During the eighth pregnancy the right lobe began to grow larger and the isthmus became very perceptible. Pain and dyspnœa became

[1] Billroth: *Die Allgemeine Chirurgische Pathologie, etc.*, 1882, p. 870.
[2] *Journ. Am. Med. Ass.*, Oct. 8, 1887, p. 472.

very marked, and were rapidly aggravated with the progress of gestation. During the latter half of this pregnancy the patient was compelled to assume a semi-recumbent position at night. During the last three months she was obliged to sit up at night supported by pillows. This posture, which she was often compelled to assume during the day, exerted a pressure upon the fundus uteri sufficient to cause an elongation of the transverse and a shortening of the vertical diameters, resulting in a total transformation of the form of the uterus into that of a transverse oval.

June 1, 1884, Dr. Caldwell was summoned to attend the woman in her confinement. He found her threatened with asphyxia and the fœtus presenting transversely. Podalic version by Braxton Hicks' method was performed, and the child safely delivered. On the fourth day afterward, contrary to instructions, the woman resumed her customary household duties.

October 16, 1885, Dr. Caldwell was again called to attend the woman in confinement. During this her ninth pregnancy, the tumor had grown much larger, and the pain and dyspnœa had increased proportionately. The woman was not so profoundly asphyxiated as in her eighth labor, since she had summoned the physician earlier. The fœtus was found presenting transversely, with the right arm and pulseless cord protruding through the vulvar orifice. The dead child, weighing nearly twenty pounds, was successfully delivered by podalic version, and the patient left her bed, as before, on the fourth day of the puerperium.

February 18, 1887, Dr. Caldwell saw the woman in her tenth confinement. The tumor had increased in size, measuring eighteen inches transversely over the isthmus; augmented pain and dyspnœa. Transverse presentation; delivery of a living child, weighing twelve pounds, by podalic version. Puerperium as before.

Nov. 26, 1887, *status præsens*. The tumor has diminished one-fourth in size, and the woman suffers no pain nor dyspnœa. Her health in other respects is perfect. Careful examination of the heart reveals no enlargement. The children showed no congenital enlargement of the thyroid, and no symptoms have appeared as yet to indicate the transmission of the so-called goitrous diathesis. This remarkable case presents the following points of interest:

I. The apparent absence of any hereditary or endemic influence or strumous diathesis in the development of the goitre. The disease seems to have been clearly due to pregnancy.

II. Alarming asphyxia usually began about the seventh month of pregnancy.

III. The posture of the woman undoubtedly exercised an important influence in the alteration of the form of the uterus and in the determination of transverse presentations.

Roberts[1] has reported three cases of goitre occurring in primiparæ. The tumors were apparently incident to pregnancy, and all three cases terminated fatally by asphyxia.

In forming a prognosis and in the institution of treatment the fact must be borne in mind that apart from the immediate danger of asphyxia the hyperplastic changes of goitre may be the point of departure of carcinoma.

TREATMENT.—It is questionable whether women of the so-called goitrous diathesis or those in whom the thyroid is already considerably enlarged should become pregnant.

Medicines, exhibited per os or applied locally, are of very limited value after the swelling has attained considerable proportions. In the early stages iodine, applied locally, is entitled to a trial. The local application of the biniodide of mercury is a favorite method of treatment in the tropics.[2] In the East Indies and in South America it is customary to rub an ointment (three drachms biniodide of mercury to one pound of lard) into the skin over the tumor in the morning. A fresh portion is then applied and left to undergo resorption, while the tumor is exposed to the rays of the sun. Macleod has seen much good result from this mode of treatment in Scotland, where fire-heat was substituted for the sun's rays.

Lücke and Schwalbe recommend parenchymatous injections of tincture of iodine. Ergotin, alcohol, iodoform (R. Iodoformi, Glycerin, Aquæ destill., *āā*. partes æqual. Mucil. gummi arabici q. s., ut fiat emulsio), carbolic acid (5 per cent. solution), are also used for the purpose of parenchymatous injection. It is scarcely necessary to state that the skin, needle, and the drug employed must be absolutely free from all pathogenic micro-organisms; otherwise there is grave danger of inflammation and septicæmia, as in the case cited by Billroth.[3]

The various preparations of iodoform exhibited per os are very much less efficient than when applied locally.

In the event of threatened asphyxia, two operations come up for consideration—tracheotomy and the induction of abortion, or more commonly the induction of premature labor. The indications for each operation are usually perfectly clear. When asphyxia is imminent, tracheotomy is indicated; when the element of time is not so important, the artificial evacuation of the uterine contents.

In recent years the technique of total extirpation of the enlarged thyroid gland has reached such a high degree of perfection, and the mortality of the operation has been reduced to such a small figure, chiefly as the result of Billroth's labors, that the procedure merits consideration. The state of pregnancy, *per se*, is not a contraindication.

[1] *Am. Journ. Med. Sci.*, October, 1876.

[2] Monat: *Indian Annals of Medical Sciences*, 1857.

[3] *Loc. cit.*, p. 873.

It must be remembered, however, that in this operation, even to a greater degree than in Cæsarean section, the experience and skill of the operator determine the force of the indication and the conduct in the concrete case.

Disorders of the Alimentary Canal.

The Pernicious Vomiting of Pregnancy.—Nausea, even vomiting, in the morning, before or shortly after meals, during the early months of gestation is so common and devoid of injurious effect that it is regarded as physiological. The incoercible, pernicious vomiting of pregnancy, in which the stomach retains absolutely nothing, is a very grave disorder. The beginning of the affection is gradual. A slight increase in the familiar morning sickness is observed, and the patient vomits at various periods through the day. She complains of loss of appetite and disgust for certain articles of food for which she formerly evinced desire. The secretions of the salivary glands are increased. Changes in the mental condition are apparent, and the woman becomes irritable, despondent, or apathetic. Horwitz[1] observed in two cases the periodical occurrence of increased sensitiveness of the sense of smell. These perceptions are often purely subjective, but they are nevertheless sufficient to increase the nausea, just as in hyperosmia from other causes.

Nausea becomes more intense, while pyrosis and hiccough are constant and distressing symptoms. The intervals between the attacks grow shorter, until the vomiting, accompanied by violent retching, becomes almost continuous. The stomach finally becomes so irritable that neither food nor drink is retained, and even the very thought of either provokes an attack. The patient throws up glairy mucus, clear or colored with bile. Ultimately, the vomit is mixed with blood. The woman is worn out and restless from loss of sleep and the painful efforts at vomiting. Very soon she begins to lose in weight, and symptoms closely resembling those of acute starvation appear. The buccal cavity is dry, the tongue red and shining, the teeth and gums covered with sordes, the breath horribly fetid, the skin dry and harsh. Extreme thirst is constant; salivation is frequently observed. In exceptional cases the loss in weight is insignificant, and the woman may perish without any sensible alteration in the subcutaneous adipose tissue.[2] Diarrhœa is observed more frequently than constipation, although there is no uniformity with reference to the changes in the functions of the intestinal tract.

Fever of a continued type, with a quick, rapid, thready pulse, is commonly developed. This symptom is not constant, as numerous observers—Zweifel, Rosenthal, Horwitz—have failed to detect any

[1] *Zeitschr. f. Geb. u. Gyn.*, Bd. ix. p. 110.

[2] Rosenthal: *Berl. klin. Wochenschr.*, 1879, No. 26.

considerable elevation of temperature. Dubois[1] and observers of the American, French, and English schools, however, have accumulated clinical observations sufficient to establish the fact of its occurrence in the majority of cases. Icterus occasionally appears in the course of the fever.

The causation of this febrile condition is unknown. Septicæmia from intra-uterine changes cannot be invoked, since the fœtus is usually alive when the fever first develops. Robert Barnes refers it to an alleged blood-poisoning from "the rapid disintegration of all the tissues, most marked in the fat-tissue."

The belly becomes tender on pressure and tympanites is developed. The urine is sparingly secreted, concentrated, and contains albumen and tube-casts. In general, the changes in this secretion are analogous to those found in acute starvation. According to Voit, the excretion of urea is usually, but not invariably, diminished.

During the last stage of the disease the vomiting abates or ceases entirely, while the fever increases and the pulse grows small and frequent. Syncope is frequent; hallucinations and delirium supervene, and the patient dies in coma or is carried off suddenly by some intercurrent malady.

Between the slight nausea upon rising in the morning and the state of extreme marasmus thus briefly sketched every degree of pathological variation may be observed.

It is a remarkable fact that the incessant vomiting, retching, and hiccough seldom interrupt pregnancy until shortly before the termination of the disease, when the loss of blood and muscular exertion consequent upon the expulsion of the product of conception from the uterus may precipitate the lethal issue. Occasionally, spontaneous abortion occurs early in the course of the disorder before the patient's condition is desperate. Then the vomiting commonly ceases at once.

In cases of gloomiest prognosis the same sudden cessation of the vomiting is sometimes seen without any apparent cause for the change. This alteration for the better is often observed after quickening, rapid eccentric hypertrophy of the uterus, and after the death of the fœtus.

The course of the disorder is chronic. Cases terminate in recovery or death in from six weeks to three months. Alarming symptoms are commonly developed between the second and fourth months; very seldom between the fourth and sixth months; still less frequently at a later period.

Fortunately, the pernicious vomiting of pregnancy is a rare affection. So few cases are recorded in German medical literature that Hohl[2]

[1] "Leçon de M. P. Dubois, par M. Laloris." *Union médical*, 1848 and 1852.

[2] Kleinwächter: *Grundriss d. Geburtshülfe*, 1881, p. 197; *Lehrb. der Geb.*, 2te Aufl., 1862, p. 728.

denied the existence of the affection. Carl Braun,[1] in a fabulous experience of over one hundred and fifty thousand obstetrical cases, has never observed a single fatal termination. On the other hand, Robert Barnes[2] has himself seen 9 fatal cases. McClintock[3] remarks: "With a very moderate amount of research I have been able to collect close on fifty authentically-recorded cases, and I know of others which have not been published." O. W. Doe[4] has collected 48 cases of this disorder, with 18 deaths, all occurring within the last ten or fifteen years and registered in American and English journals. Guéniot[5] records 118 cases, with 46 deaths. This diversity in the observation of accomplished obstetricians is suggestive. It seems hardly probable that national characteristics, the environment, or other conditions are adequate to the creation of such essential changes in the course of this disorder. It is a noteworthy fact that in many of the cases of death from alleged hyperemesis of pregnancy the diagnosis was not verified by post-mortem examination.

The affection is of more frequent occurrence among primigravidæ than among multigravidæ. Rosenthal,[6] indeed, has collected 100 cases, of which 67 were multiparæ and 33 primiparæ; but, as pointed out by Horwitz, these cases cannot all be referred to the category of the hyperemesis of pregnancy.

Etiology.—The oldest and most generally accepted view of the pathogenesis of this disorder is that it is a reflex phenomenon. As the essential predisposing causes it is necessary to bear in mind the changes in the constitution of the blood and the alterations in the functions of the nervous system incident to pregnancy. The germinal mass within the uterus gives origin to numerous peripheral irritants. There is nothing strange nor out of the usual course of nature in this manifestation. Reflex nausea, or even vomiting, is by no means an uncommon symptom in various morbid states of the womb in the non-gravid woman. Thus, this symptom is sometimes observed in chronic metritis and pathological conditions of the vaginal portion. Tilt records a case of fatal hyperemesis alleged to have been caused by a uterine fibroid. Opinions, however, differ widely as to the exact nature of the peripheral irritant.

Bretonneau insisted upon the importance, as an etiological factor, of the stretching of the uterine fibres by the growing ovum, and the consequent compression or irritation of the nerves distributed to this viscus. There are many facts in support of this theory of passive uterine distension. Hyperemesis is of more frequent occurrence and of a severer type, as a rule, in the primigravida than in the multigravida. It is

[1] *Loc. cit.*, p. 842.
[2] *Loc. cit.*, p. 274.
[3] *Dubl. Journ. Med. Sci.*, 1873.
[4] *Boston Med. and Surg. Journ.*, Feb. 11, 1886.
[5] *Thèse Agrégation*, 1863.
[6] *Loc. cit.*

commonly observed during the first half of pregnancy. It is of frequent occurrence in cases of passive distension of the uterus, as in multiple pregnancy, hydramnion, and hydatidiform mole. Immediate cessation of all symptoms is commonly noted after quickening, rapid growth of the uterus, death of the fœtus, and evacuation of the uterine contents; that is, when the factor of mechanical distension is eliminated.

Graily Hewitt[1] has attached great significance to flexions and versions of the uterus as causes of the affection under consideration. The nerves from the cervical ganglion are pinched at the angle of flexure or are compressed by the inflammatory changes incident to the alteration in the form or position of the womb. He explains the morning attack and the aggravation of the vomiting when the patient is erect by asserting that the flexion or displacement is at the same time increased by the superincumbent intestinal mass. This hypothesis offers an entirely inadequate explanation, since the uterus has been found to be of normal form and position in many of the recorded cases of hyperemesis, and in very many cases of anteflexion and retroflexion with corresponding displacements the vomiting has been notably absent. It is not at all improbable, however, that in a limited number of cases this factor plays an important rôle.

J. H. Bennet,[2] in particular, has directed attention to pathological conditions of the vaginal portion—inflammatory states, and especially erosions and excoriations of the os externum—in their causal relation to this disorder. It is altogether probable that the operation of this cause is more extensive than clinical observers have been disposed to admit. A case in point has recently come under the writer's observation. A vigorous young woman passed through her first pregnancy without the common morning sickness. During parturition an extensive bilateral laceration of the vaginal portion occurred. The puerperium was perfectly normal and involution of the genital tract apparently complete. Two years later she became pregnant for the second time, when she began to complain of morning sickness, rapidly developing into pernicious vomiting. It was possible to exclude inflammations of the uterine musculature, peritoneum, and mucous membrane, and attention to the local condition of the vaginal portion apparently relieved the hyperemesis. Numerous similar cases are on record.

The anatomical relations of the vaginal portion to the cervical ganglion, and the favorable influence of certain therapeutic measures addressed to this organ, lend great probability to Bennet's theory. Nevertheless, it cannot be accepted as a universal explanation, since erosions, and even extensive lacerations, are often present in the entire

[1] *Transactions of the Obstetrical Society of London*, 1872, p. 103.

[2] "On Obstinate Sickness during Pregnancy," *Brit. Med. Journ.*, June 12, 1875.

absence of the disorder, and, on the other hand, hyperemesis sometimes occurs when the vaginal portion is in a perfectly normal state, so far as may be ascertained by the means at disposal.

Horwitz and others are inclined to assign to parenchymatous inflammation of the uterine parietes the chief rôle in the causation of the majority of cases of hyperemesis. Pregnancy occurs in a uterus already the site of chronic metritis. The uterus is of larger size than in correspondence with the epoch of gestation, and it is also abnormally sensitive, with diminished mobility. Horwitz also emphasizes the causal importance of inflammations of the pelvic connective tissue and peritoneum—a view to which Joulin[1] has previously given expression.

A more important etiological factor than chronic metritis, but one to which this condition undoubtedly predisposes, consists in endometritis gravidarum—a morbid state to which Ebell and J. Veit[2] in particular have directed attention in recent years. Pregnancy almost invariably exerts an unfavorable influence on chronic endometritis; under the stimulus of the increased nutritive energy of the mucosa incident to pregnancy formative changes rapidly occur which not infrequently lead to abortion or premature labor. Veit records three cases in which these changes stood in causal nexus with hyperemesis, the diagnosis being confirmed by the macroscopical and microscopical characters of the decidua serotina and vera.

Probably in the very large majority of cases the excentric irritant consists in some morbid change in the form or position of the uterus, the condition of the vaginal portion, the uterine parenchyma, the pelvic peritoneum and connective tissue, the endometrium, either alone or in combination. In a certain class of cases, however, the pathogenesis of the disorder is to be found in the exaggeration of some morbid condition of the gastric or intestinal mucous membrane, which prior to gestation was not sufficient to seriously attract the patient's attention, but which under the influence of pregnancy develops into hyperemesis. No causal relation has been demonstrated between pregnancy and simple gastric ulcer, but, given the latter condition, the morning sickness of pregnancy aids in the development of a formidable disease. The changes in the blood, and consequent local disturbances in the circulation of the gastric mucosa, leading to the formation of ulcer (Rokitansky, Virchow), cannot be invoked, since, as before remarked, these changes are chiefly pronounced during the second half of pregnancy. Horwitz records a case of fatal hyperemesis of pregnancy in which chronic catarrhal gastritis had existed for some time prior to conception. The slight tendency to nausea and vomiting at once became exaggerated, and the patient died of exhaustion, notwithstanding the artificial induction of

[1] *Traité complet d'Avortement*, Paris, 1867.

[2] *Berl. klin. Wochenschr.*, 1887, No. 35, p. 643.

abortion. The autopsy revealed phlegmonous inflammation of the stomach with important diminution of its lumen. In another case terminating fatally from exhaustion and septic toxæmia, notwithstanding the spontaneous occurrence of premature labor, the same observer noted polypoid new formations of the mucous membrane of the colon as the cause of vomiting. The neoplasmata were located in the colon long before conception, but under the influence of gestation they had apparently grown so rapidly that the reflex irritation was sufficient to provoke fatal hyperemesis. Horwitz[1] has formulated the facts just indicated in the following proposition: "The greater the disposition of any section of the alimentary canal to a morbid state, the greater the ease with which the vomiting of pregnancy becomes uncontrollable."

The mechanism of the reflex vomiting of pregnancy has been the subject of recent investigation. Tumas,[2] from experiments on cats and dogs, localizes with tolerable precision the situation and extent of the vomiting centre. He asserts that it lies in a small space before and behind the calamus and in the deeper layers of the medulla, near to or in close communication with the centre which, by inference, presides over the organs of generation.[3] The two distinct qualifications common to all organisms are—(1) self-maintenance, and (2) the perpetuation of the species. A close relationship therefore throughout life exists between the processes of assimilation and reproduction, and it is probable that their representative nerve-centres act and react upon each other. "When the uterus becomes the nidus for a developing germinal mass, the molecular disturbances radiated therefrom to the reproductive centre are liable to be transmitted to the pneumogastric as well, and induce either a feeling of nausea or actual emesis. Usually, however, in the course of a few months, through habit, the pneumogastric centre becomes tolerant, and the symptom evidencing disturbance at the same time disappears." But the nervous system of the pregnant woman is uncommonly susceptible to molecular radiations, and the latter are liable to augmentations and modifications from pathological conditions in connection with the womb, so that the normal morning sickness is developed into pernicious vomiting. Oliver suggests, in explanation of the fact that the nausea and vomiting of pregnancy occur in the morning, that the change "from the recumbent to the erect position after sleep renders the whole nervous system more liable to explosive disturbances." Epileptics often experience seizures only upon rising after sleep.

Lebert and Rosenthal are of the opinion that certain cases of hyper-

[1] *Loc. cit.*, p. 161. [2] *Lancet*, Oct. 1, 1887.

[3] James Oliver: "The Cause of the Morning Sickness during Pregnancy," *Brit. Med. Journ.*, Oct. 1, 1887, p. 717.

emesis are referable to a general inanition of the nervous tissue in connection with, or in the absence of, peripheral irritants in the uterus or morbid states of the alimentary canal. Kiwisch found a sufficient cause in the relation between the hyperæsthetic gastric nerves and the hydræmic condition of the blood during pregnancy. Frerichs has pointed out the connection of hyperemesis with the renal inadequacy of Bright's disease. Such cases, however, are plainly not due immediately to pregnancy, and cannot be discussed under the topic now being considered.

Race, social condition, and temperament would seem, from the widely-different views upon the frequency of the occurrence of this disorder, to exercise an almost determining influence. As before remarked, comparatively few severe cases are recorded in German medical literature. Ahlfeld[1] has only observed three cases in which he seriously considered the artificial interruption of pregnancy. In each of these cases it was possible to alleviate the disorder without recourse to the evacuation of the uterine contents. Winckel and Cohnstein have been equally successful in the treatment of this disorder and by similar therapeutic means. On the other hand, P. Dubois[2] asserts that he himself observed twenty fatal cases. Mention has already been made of the alleged comparative frequency of the disorder in America and England. The nature of this influence, if its existence be admitted, is purely conjectural.

This brief sketch of the causation of the pernicious vomiting of pregnancy does not exhaust the numerous ingenious theories and hypotheses, more or less adequately explanatory of certain cases, with which the literature of the subject abounds. Notwithstanding the extent and, in general, the accuracy of etiological research into the nature of the disorder, a class of cases still remains in which no organic change capable of objective demonstration can be found. This class of cases, however, is constantly diminishing in number.

Diagnosis.—The diagnosis of the pernicious vomiting of pregnancy is not so easy as at first seems apparent. It is not at all improbable that the difference of opinion as to the frequency of this disorder between the Germans upon the one hand and the American, French, and English observers upon the other, depends in a large measure upon the difference in diagnostic criteria insisted upon by the respective schools. In the majority of the fatal cases of alleged hyperemesis due to pregnancy reported by American, French, and English observers there is, as before remarked, a notable absence of reliable records of post-mortem examinations. In the few cases collected by the Germans, on the other hand, the diagnosis *in viva* has almost invariably been confirmed or negatived by exact investigation of the dead body.

[1] *Arch. f. Gyn.*, Bd. xviii. p. 310.

[2] *Loc. cit.*

Horocks[1] pertinently remarks: "Where there has been no post-mortem examination in a fatal case of vomiting, I do not think one is entitled to say that the pregnancy caused the fatal vomiting. It may have been the cause, and the only cause, or it may have been an aggravation of some other cause, or it may have had nothing to do with it." Scepticism as to the alleged frequency of this disorder in the present state of our knowledge is accordingly eminently in order.

Until the major premise as to diagnosis is adequately determined, it is not only useless, but deplorably unwise, to speculate as to the possible influence of race, temperament, environment, and the like. Incidentally, it may be remarked that the influence of such conditions upon this aspect of pregnancy is absolutely hypothetical. There are no facts in our possession which would indicate a lesser degree of nervous susceptibility in the Teutonic pregnant female than in her American, French, English, or Russian sister.

Guéniot[2] calls attention to three distinct elements in the diagnosis of the pernicious vomiting of pregnancy:

I. The diagnosis of pregnancy. This element in the diagnosis usually involves no especial difficulty when the pregnancy is advanced to the twelfth week, but before this period it is only in exceptional cases that a positive judgment can be formed.[3]

II. The diagnosis of the adjuvant or determining cause of the vomiting. In the large majority of cases the adjuvant or determining cause consists in some morbid change in the uterus which is not always capable of objective demonstration. In chronic interstitial decidual endometritis the diagnosis is commonly made only after expulsion of the ovum and the examination of the fœtal envelopes. In hydrorrhœa gravidarum, however, the symptoms are often sufficient to establish the diagnosis. When the vomiting is due to the aggravation of some previously-existing condition, as chronic gastritis and gastric ulcer, the history of the case yields important data. It is perhaps needless to remark that success in treatment depends in a large measure upon the adequacy of the recognition of this element in the diagnosis.

III. The differential diagnosis between the obstinate vomiting due to pregnancy and the obstinate vomiting due to other causes entirely independent of gestation. The most eminent clinicians have committed grievous errors in diagnosis, especially in this element. Thus, Trousseau[4] once made the diagnosis of uncontrollable vomiting and induced abortion in a case in which the autopsy

[1] *Brit. Med. Journ.*, 1886. [2] *Loc. cit.*

[3] Thus, Cazeaux narrates the history of a fatal case of alleged hyperemesis of pregnancy in which the autopsy disclosed tubercular peritonitis and the absence of pregnancy.

[4] Depaul.

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